In this Issue: A New Dynamometer Car.—The Design of Wooden Trestles.—The Flow of Water in Irrigation Canals.—A Comparison of Different Types of Sewage Filters.

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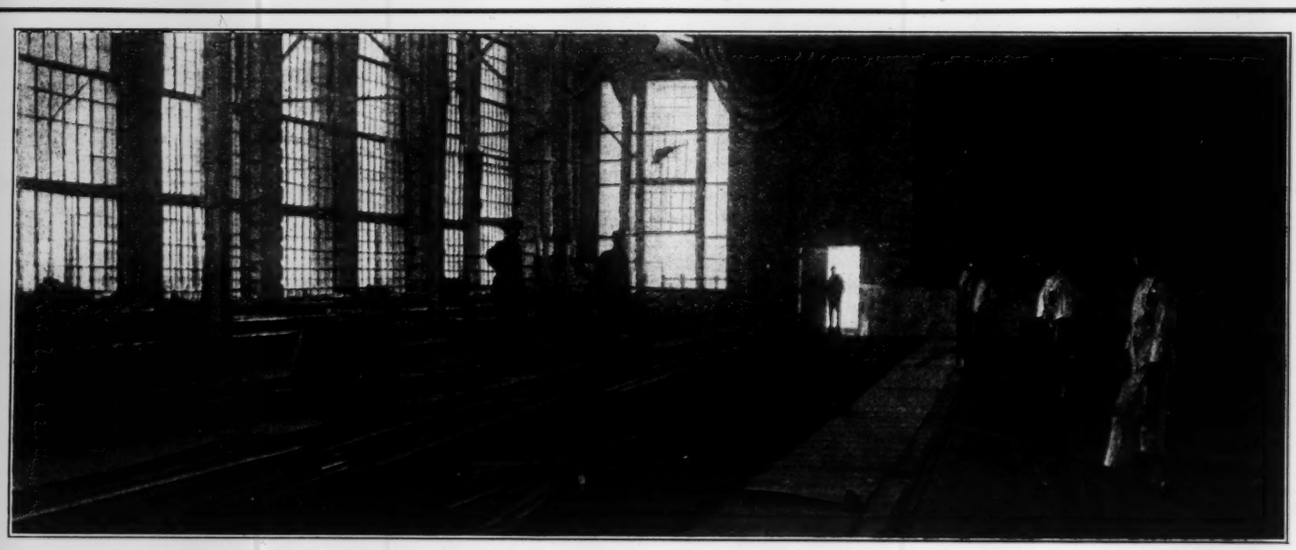

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EXCAVATING MACHINES ON THE NEW YORK STATE BARGE CANAL.

We published some years ago a series of articles on the Chicago Drainage Canal, then in course of construction, in which were illustrated and described a great number and variety of excavating machines used on that work. The construction of the Barge Canal for the State of New York, which is now well under way, has given rise to problems in excavation very similar to those solved in the Chicago work and the devices used on the various divisions bid fair to rival in interest the ones used on the Drainage Canal. We show here several photographs of one special type now in operation about three miles west of Rochester, N. Y., on the contract of F. A. Maselli & Co.

This contract covers a length of over two miles of heavy cutting in nearly 30 ft. of rock overlaid with two or three ft. of earth. Fig. 1 shows the entire machine as first designed for the work. The truss is 420 ft. long and is on towers 56 ft. high; the whole framework weighing about 350 tons. It is designed to travel on standard gage tracks (see Fig. 3) on each side of the excavation. Fig. 2 illustrates the grab or clam-shell bucket with which the traveler was first equipped. This bucket holds about 8 cu. yds. of material and was expected to load automatically with earth or rock which had been well broken up. The machine began operation in May, 1906, and it was soon found that not more than 2 or 3 cu. yds. could be loaded with the bucket. However, this method was followed until February, 1907, when a steam shovel was installed to load the bucket, as shown in Fig. 3. The grab was still continued to strip the earth surface.

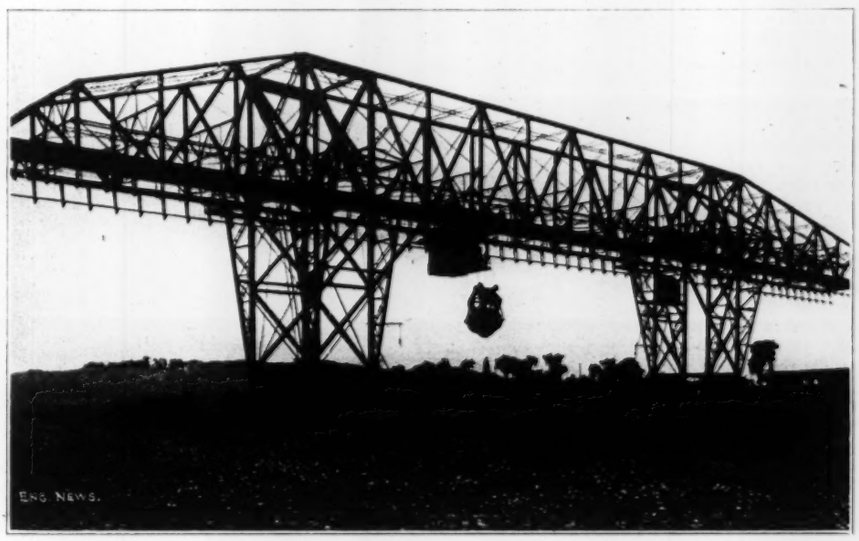

FIG. 1. GENERAL VIEW OF TRUSS EXCAVATING MACHINE ON NEW YORK STATE BARGE CANAL.

The machine is driven by electric power from the Rochester Gas and Electric Co.'s plant, a transformer station being carried in the car attached. To operate the entire system when the clam shell was used required the following force: operator in transformer station; operator in cab over grab; six laborers and a foreman. When steam shovel was added extra men were needed for its operation. It is not thought that this truss machine can be a paying proposition unless a very large amount of work can be contracted for.

On the same contract of the Barge Canal a much simpler system, shown in Fig. 4, has been operated quite successfully all winter except when drowned by water. The photograph is self-explanatory.

THE COMPARATIVE DISPOSITION OF ORGANIC MATTER BY SAND, CONTACT AND SPRINKLING FILTERS*

By H. W. CLARK.†

The primary object in sewage purification is to change by bacterial oxidation the putrefying matter or matters easily subject to putrefaction, present in sewage, to a more stable form and thus to convert an ill-smelling, objectionable liquid into one free from odor and easily decomposable matter. Only a small percentage of the total organic matters present are of this easily changeable nature, however, and it is the large remainder, both organic and mineral, that accumulates in settling tanks, causes filter clogging and is the chief element of cost in adequate sewage disposal. It is well recognized to-day that in the successful treatment of sewage upon a large scale the ultimate disposition of suspended matter presents the chief difficulty.

At the present time, three classes of sewage filters are well known and have been studied at many places: sand, contact and sprinkling, trickling or percolating filters. The object of the present paper is to show the relative amounts of total organic matter, matter in suspension, etc., that reaches such filters when operated at usual or normal rates, and the disposition that each class of filter makes of these matters. The study is largely of the organic matter in suspension in sewage.

In average Massachusetts sewage, from 50% to 75% of the matter in suspension is organic, and only from 1% to 7 or 8% is nitrogen (rarely more than 2½%), this percentage varying with different sewages and at different times with the same sewage. The remainder of the organic matter is carbonaceous, resistant to bacterial action, and hence slow to putrefy or decompose. If we look at the filtration problem from the point of view that successful purification is accomplished whenever the putrefying matters present in sewage are broken up, oxidized and rendered inoffensive, then the filter that will accomplish the greatest amount of this work upon the smallest area is the most successful filter. If, on the other hand, we consider successful filtration accomplished only when practically all the organic matter present in sewage, both stable and unstable, is removed, then a very different problem is presented. Only sand or other filters of fine material can possibly fulfil the latter requirement while contact and sprinkling filters can be made to fulfil the first requirement.

In discussing in this article the disposal of matter actually reaching each of the three classes of filters mentioned, the work of sand, contact and sprinkling filters operated at the Lawrence Experiment Station is used, and the comparisons given are based upon the work and present condition of sand filters that have been operated 19 years, contact filters that have been operated 6 years, and sprinkling filters that have been operated nearly 8 years, each and all receiving Lawrence sewage. It is of course true that similar filters, receiving the sewage of a different municipality, would give somewhat different results.

The Lawrence sewage reaching the experiment station is a strong domestic sewage, much stronger than the average sewage of American municipalities now operating sewage purification plants, and contains an amount of matter in suspension fully comparable to its strength in other respects. The matter in suspension in this sewage is more or less finely divided, but not more so than the matter in many sewages that have had a slight preliminary screening, or else sedimentation, for the removal of coarser matters in suspension, or that have traveled through a considerable length of sewer before reaching the disposal area.

The total organic matter in the average station sewage of the last 19 years has amounted to about 2,800 lbs. per 1,000,000 gals. and the sus-

*Abstract of paper read before Laboratory Section of American Public Health Association, at City of Mexico, December, 1906.

†Chemist, Massachusetts State Board of Health, Boston, Mass., and Chemist in Charge Lawrence Experiment Station.

pended matter to about 2,080 lbs. per 1,000,000 gals. The matter in suspension has had a composition about as follows: 70% organic or volatile matter and 30% mineral matter. Of the organic matter about 2.6% has been organic nitrogen and the remainder has been carbonaceous matter containing about 40% carbon, as shown by many analyses, and 22% fat or fatty matters.

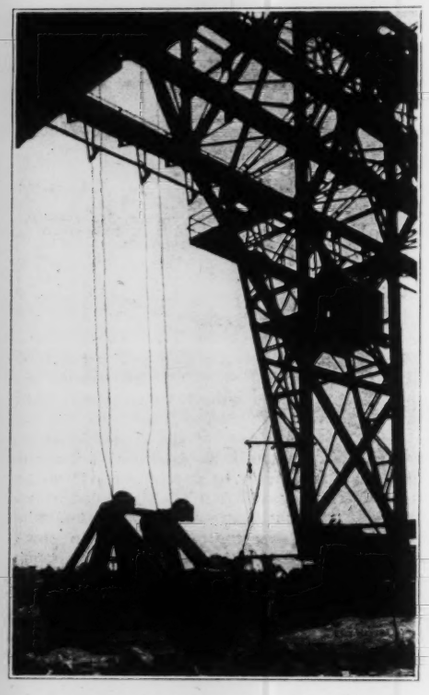

Fig. 2. Grab Bucket on Excavating Machine.

SAND FILTERS.

For nearly twenty years experimental sand filters and municipal sand filters have been operated in Massachusetts. Experimental filters operated at an average rate of about 70,000 gals. per acre daily have given an effluent nearly always clear and much of the time practically colorless, and with little or no odor. Municipal filters have been operated at average rates of from 40,000 to 60,000 gals. per acre daily with as good as or even better removal of organic matter than the experimental filters, and hence have produced effluents of fully as good and often of better quality than the experimental filters. To show by actual figures what intermittent sand filters accomplish in the disposal of organic matter, the average results of an average Lawrence experimental sand filter can be taken. This filter has been operated at an average rate of 70,600 gals. per acre daily for 19 years. The average analysis of its effluent for its entire period of operation is shown by Table I.

Table I.—Average Analysis of the Effluent of Sand Filter No. 1. (Parts Per 100,000.)

Quantity applied. (Gals.*)	Color.	—Ammonia.— Free.	Albuminoid.	Chlorine.	Nitrogen as Nitrates.	Nitrites.	Oxygen consumed.
70,600.	.36	.7492	.0674	8.45	2.28	.0197	.59

*Per acre daily, six days per week.

This effluent has been practically free from matters in suspension, probably 95 of every 100 samples collected showing none, and the other five containing so little that it would be lost in averaging. Hence it may be assumed that practically none of the organic or mineral matter in suspension in the applied sewage has appeared in this effluent.

There has been applied with each million gallons of sewage about 375 lbs. of nitrogen, and of this 18%, or 67.5 lbs., has been organic nitrogen. Of the total nitrogen applied, including both that in solution and suspension, about 55% has been oxidized and has appeared in the effluent; about 18% has been present in the effluent unoxidized; about 3% has been stored in the filter and 25% has been freed by nitrogen-liberating bacteria and passed into the air. Of the organic nitrogen applied, largely nitrogen of the suspended matters, about 65% has been oxidized, about 16% stored and about 19% has disappeared through the action of the nitrogen-liberating bacteria. The nitrogen in sewage, however, while of course forming an integral part of the organic matter that is liable to quick putrefaction, the production of bad odors, etc., and hence the portion that must be broken up by bacterial action is but a small constituent of the total organic matter. Under the right conditions for filtration it can be easily and quickly disenchained from its associated elements and the putrefying bodies eliminated. It is the non-putrefying, slowly decomposable organic matter that must be reckoned with finally, and especially the organic matter in suspension. For instance, there has been applied to Filter No. 1 in each million gallons of sewage about 2,800 lbs. of organic matter, judging from loss on ignition results, and about 2,100 lbs. of matter in suspension in the sewage, of which 70% has been organic matter. Taking into consideration the rate of filtration, there has been applied to this filter about 62,000 lbs. per acre per year of organic matter, and, of this, 32,000 lbs. has been organic matter in suspension in the sewage. There has accumulated in the filter about 10,500 lbs. of organic matter per acre per year of service, and of this only 2.5%, or 262 lbs., is organic nitrogen. Of the total organic matter applied, 17% has accumulated in the filter, but as the accumulation has been, of course, of the organic matter in suspension, the true comparison is with this. Of the 32,000 lbs. of organic matter in suspension applied per acre per year, the analytical results show a storage of 33%. Of this stored matter, 65% is in the upper foot of filtering material, but there is not enough stored as yet to prevent good operation of the filter and the production of a highly nitrified effluent. This organic matter, on account of the long period of storage of most of it and the resulting working over by bacteria, has been changed materially; in the matters in suspension in the applied sewage the fats are from 25% to 35% as great as the loss on ignition, but in the stored matter the fats are only about 2.8% as great as the loss on ignition. The amount of nitrogen in the suspended matter in the sewage has been about 6% as great as the amount of carbon in this matter, while in the stored matter it is about 2.5%. The results of the many years of operation of this typical sand filter can be summarized as follows: At an average rate of 70,000 gals. per acre daily, a rate requiring 14.3 acres per 1,000,000 gals. of sewage cared for per day, it has produced a clear, highly nitrified and generally odorless effluent, and has successfully disposed of the nitrogen in solution in the applied sewage and 84% of the organic nitrogen. It has oxidized and successfully disposed of 67% of the total applied organic matter in suspension in the sewage and has stored 33% of this matter. The residuum of organic matter stored is of an almost undecomposable, stable nature and increases slowly but continually with continued use of the filter. It is probable, however, that the relative percentage stored will decrease and the percentage oxidized will increase as the filter continues in operation. That is to say, if this filter continues in operation for another ten years, the stored matters up to that date will probably not be greater than 20% of the corresponding applied matters, and the matters oxidized will have increased to 80%, this being due to the fact that this comparatively stable matter does change slowly and shows some relative decrease.

CONTACT FILTERS.

Contact filtration has been studied at the Lawrence station for the past twelve years. For discussion in this paper I have selected three of the many contact filters operated: Nos. 175, 176 and 221.

Coke contact filters Nos. 175 and 176 have been in operation about five years and contact Filter No. 221, constructed of broken stone, about three years. The average rate of operation of coke Filter No. 175 has been about 621,000 gals. per acre daily, of coke Filter No. 176, 595,000 gals., and of broken stone Filter No. 221, 530,000 gals. per acre daily, these rates being from 7½ to 8½ times as great as those of the sand filters already discussed; or, in other words, these filters have received during each year from 7½ to 8½ times as much sewage per unit area of surfaces as the sand filters. The average analysis of the effluent of each of these filters for their period of operation is shown by Table II.

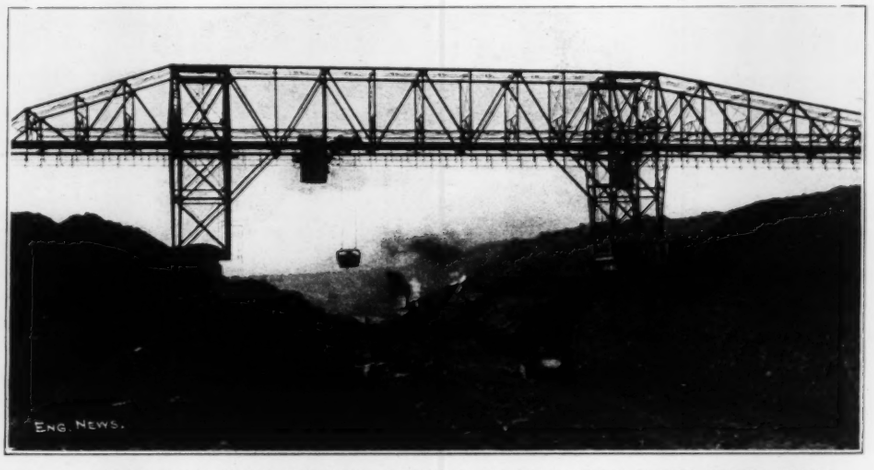

FIG. 3. LARGE EXCAVATING MACHINE WORKING ON NEW YORK STATE BARGE CANAL.
420 ft. Long. Towers 56 ft. High. Weight 350 Tons. Capacity of Bucket 8 cu. yds.

There has been applied to coke Filter No. 175 with each million gallons of sewage about 2,130 lbs. of organic matter, this filter having received strained sewage; to Filter No. 176, 2,770 lbs., and to stone Filter No. 221, 2,810 lbs. with each

TABLE II.—AVERAGE ANALYSIS OF THE EFFLUENTS OF CONTACT FILTERS NOS. 175, 176 AND 221 DURING THEIR PERIOD OF OPERATION.
(Parts per 100,000)

Quantity applied. Gallons per Acre daily, for 6 days in a week.	Color.	—Ammonia— Free.	Total.	—Albuminoid— In solution.	Chlorine.	—Nitrogen as— Nitrates.	Nitrites.	Oxygen consumed.
				Filter No. 175.				
620,800	.57	1.1290	.1887	.1302	11.16	1.97	.0307	1.32
				Filter No. 176.				
594,700	.68	1.5384	.2065	.1455	10.57	0.91	.0195	1.42
				Filter No. 221.				
536,300	.94	2.1921	.2888	.2055	10.79	0.16	.0069	1.80

million gallons of sewage. In other words, taking into consideration the rate of filtration of each, about 400,000 lbs. per acre per year to coke Filter No. 175; 494,000 lbs. to coke Filter No. 176 and 450,000 lbs. per acre per year to stone Filter No. 221, or from 6 to 8 times as much per acre per year to these filters as to the sand filter previously discussed. Each million gallons of sewage applied to the various filters has contained an average amount of suspended matter as follows: Filter No. 175, 800 lbs.; No. 176, 1,760 lbs.; No. 221, 1,710 lbs. These figures correspond to about 149,000, 314,000 and 278,000 lbs. per acre per year applied to Filters Nos. 175, 176 and 221, respectively. Of the suspended matter, practically 75% has been organic; hence, coke Filter No. 175 has received about 112,000 lbs. of organic matter in suspension per acre per year; Filter No. 176, 236,000 lbs.; Filter No. 221, 206,000 lbs. Filter No. 175 has received with each million gallons of sewage about 350 lbs. of nitrogen and of this about 23%, or 70 lbs., has been organic nitrogen. The corresponding figures for Filters Nos. 176 and 221 are 390 and 78 lbs., and 280 and 114 lbs., respectively. Of the total nitrogen applied to Filters Nos. 175, 176 and 221 there has appeared oxidized in the effluent of each 49%, 19% and 4%, respectively; 2%, 1% and 10% of the total applied nitrogen has been stored; and 18%, 46% and 37% for each filter, respectively, liberated. Of the organic nitrogen applied to Filters Nos. 175 and 176, 6% has been stored, and Filter No. 221 has stored 32% of the organic nitrogen applied. Of the total organic matter applied, Filter No. 175 has stored 5%; Filter No. 176, 6%, and Filter No. 221, 26%. Of the suspended solids in the sewage, they have stored 13%, 8% and 36%, respectively, and of the organic matter in suspension applied, they have stored 17%, 10% and 47%, respectively, or relatively, 60%, 3.6% and 168% as much as the sand filter already discussed. Of solids in suspension, Filter No. 175 has stored 19,400 lbs. per acre per year; Filter No. 176, 25,000 lbs. per acre per year and Filter No. 221, 98,000 lbs. per acre per year. In other words, they have stored about 100, 135 and 610 lbs., respectively, of suspended matter for each million gallons of sewage applied, and of this stored matter 45% is organic. These filters have produced effluents of varying character: Filters No. 175 and 176, effluents with much of the easily putrescible matter of the sewage oxidized or removed and hence, generally, stable effluents, notwithstanding the large amount of organic matter present, while Filter No. 221 has produced much of the time an effluent subject to putrefaction. These filters require about 1.7 acres of surface per million gallons of sewage treated per day.

TABLE III.—AVERAGE ANALYSES OF THE EFFLUENTS OF FILTERS NOS. 135 AND 136 DURING THEIR PERIOD OF OPERATION.

Quantity Applied. Gallons per Acre Daily.*	Color.	(Parts per 100,000.) Ammonia. Free.	Albuminoid. Total.	Albuminoid. In solution.	Chlorine.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen Consumed.
			Filter No. 135.					
1,531,400	.71	1.7915	.2020	.1158	9.64	2.26	.0083	1.59
			Filter No. 136.					
1,667,600	.70	2.0728	.2381	.1292	9.70	2.10	.0113	1.83

*Filters operated during some years 7 days a week; during other years, 6 days a week.

SPRINKLING FILTERS.

For the third comparison of the disposition of matter by filtration, the results of two sprinkling filters that have been in operation eight years are presented. These two filters are constructed of broken stone and have received sewage at an average rate of 1,600,000 gals. per acre daily; a rate requiring only .6 of an acre per 1,000,000 gals. of sewage treated.

During some of the years of their operation they have received raw sewage, and during other years, sewage from which a portion of the matters in suspension have been removed either by septic tanks or mechanical strainers. Averaging the results of these two filters, the following data are obtained: With each 1,000,000 gals. of sewage there has been applied 2,300 lbs. of total organic matter and 875 lbs. of organic matter in suspension, or about 420,000 lbs. of organic matter in suspension in the sewage applied to each filter per acre per year. The filters have stored 4% of the total suspended matter applied; and about 5½% of the organic matter in suspension in the applied sewage, the latter amounting to 23,000 lbs. per acre per year or about 50 lbs. per 1,000,000 gals of sewage. There has been applied with each 1,000,000 gals. of sewage 375 lbs. of nitrogen, and of this about 17%, or 64 lbs., has been organic nitrogen; hence each filter has received 28,000 lbs. of organic nitrogen per acre per year, this organic nitrogen being about 7½% of the applied suspended solid matters. The filters have stored 1% of the total nitrogen applied and 6% of the organic nitrogen. About 42% of the applied nitrogen has appeared oxidized in the effluent, 43% has appeared unoxidized, 14% has been liberated and 1% has been stored. Average analyses of effluents of these two filters are given in Table III.

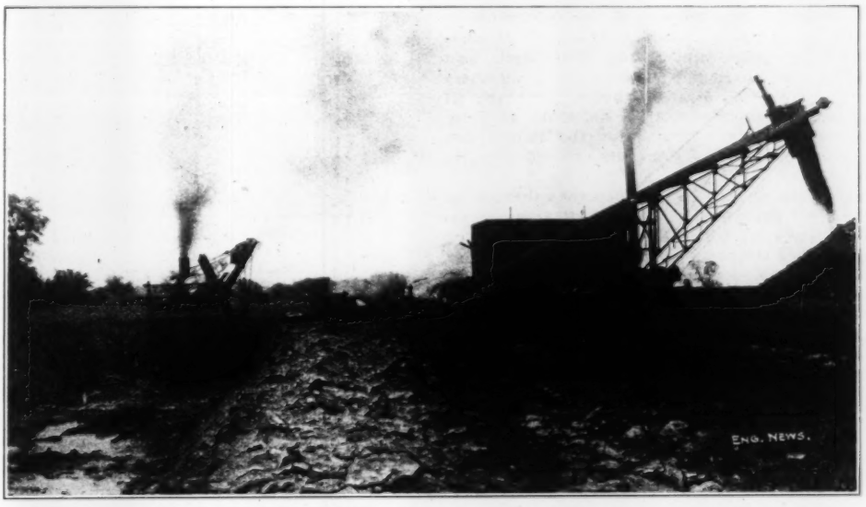

FIG. 4. STEAM SHOVEL AND INCLINE CARRIER ON NEW YORK STATE BARGE CANAL.

SUMMARY.

All these results show clearly the true function and action of the three classes of filters in handling the large amount of fairly stable matter, organic and mineral, that reaches them. [Besides the preceding text, see Table IV. for a tabular summary of figures for the various filters.] Oxidation of the matter actually putrefying at the time of application of the sewage is generally easily accomplished by any properly operated filter. This being done, a good sand filter, owing to oxidation and straining, produces a clear, practically odorless and highly-nitrified effluent. The rate at which it can be operated is limited, however, and can rarely exceed 100,000 gals. per acre daily when receiving a normally strong sewage. Preliminary treatment of the sewage, of course, allows this rate to be materially increased. Contact filters allow rates 6 to 8 times as great as sand filters, but only the best give non-putrescible effluents. Trickling filters can be operated with normal sewage at rates at least 3 or 4 times as great as contact filters and 20 times as great as sand filters, with the production of a highly nitrified, practically odorless and non-putrescible effluent—generally a quite turbid effluent, however. Sand filters, owing to their comparatively low rate of operation, may be many years in accumulating enough stable organic matter within the sand to necessitate its removal or cause difficulty in operation. A considerable percentage of the stable organic matter applied and passing below the surface does, however, accumulate. The best of contact filters, on the other hand, and good trickling filters, succeed in oxidizing the putrefying matters present in the sewage as applied to them, and owing to the nature of the materials of which they are constructed accumulation of matter within them is slow, as these filters pass along most of the non-putrefying, stable organic and mineral matters of the applied sewage. Poor contact filters and trickling filters of fine material may, however, accumulate matter rapidly. The percentage of this matter stored by the best trickling filters at Lawrence is slight and apparently does not gain beyond a certain point, as shown by our analyses and examinations. The peeling of this matter from the filtering materials at times of bacterial activity, and its passage in large quantities into the effluent, has been frequently noted in the Lawrence reports.

In conclusion, then, this paper is simply a collection of data to show with some degree of accuracy what the final disposition of organic matter by various types of sewage filters really is.

TABLE IV.—COMPARATIVE DISPOSITION OF ORGANIC MATTER BY SAND, CONTACT AND SPRINKLING OR PERCOLATING FILTERS AT THE LAWRENCE EXPERIMENT STATION.

	Sand filter.	Sprinkling filter— No. 135.	Sprinkling filter— No. 136.	Contact filter— No. 175.	Contact filter— No. 176.	Contact filter— No. 221.
Per Cent. of Applied Matter Stored in Filters.						
Total nitrogen	3	1	1	2	1	10
Organic nitrogen	16	6	6	6	6	32
Organic solids	..	2	2	5	6	26
Solids in suspension	33	4	4	13	8	36
Percentages of Organic Matter and Organic Nitrogen Applied and Stored.						
Organic matter in solids in suspension	70	74	74	73	75	75
Organic nitrogen in solids in suspension	3.3	6	9	6	5	5
Organic nitrogen in stored matter	2.5	8	8	3	6	6
Organic matter in stored matter	..	55	60	45	46	43
Stored organic matter to suspended organic matter in applied sewage	33	5	6	17	10	47
Pounds of Organic Matter Applied and Stored.						
Total in suspension, applied per acre per year	32,000		420,000	112,000	236,000	206,000
Stored per acre per year	10,500		23,000	19,000	25,000	50,000
Stored per 1,000,000 gals. of sewage applied	477	48	50	100	135	610
Per cent. of Applied Nitrogen.						
In effluent, oxidized	55	37	47	49	19	4
In effluent, unoxidized	18	39	47	31	34	49
Stored in filter	3	1	1	2	1	10
*Liberated	25	23	5	18	46	37

*By difference.

We no longer imagine that we can, by bacterial action in properly constructed filter beds, dispose of all organic matter. Much of it is too stable for such disposition; it will accumulate. In sand filters its accumulation is slow simply because the rate of filtration is necessarily low. There is much talk at the present time of higher rates of filtration through sand filters, and if poorer purification can be allowed and frequent sand removal resorted to economically, these higher rates are allowable. Sprinkling filters and the best contact filters give a less degree of purification, estimated by the matter oxidized or matter strained out, but allow the greater rates shown here, oxidize the putrefying matters and pass along a large percentage of the stable matter.

HINTS ON THE DESIGN AND CONSTRUCTION OF WOODEN TRESTLES.

By R. BALFOUR.*

Heretofore the predominant idea appears to have been that a timber trestle is a structure of a very temporary nature, which does not require care in its design nor good workmanship in its erection; whereas if the same care were used in calculating the strains and strength of materials in a wooden trestle as are applied in designing steel trestles, there would be quite a different attitude on the subject.

In providing for the conditions under which the timber has to do its work, the value of its actual working strength is almost an unknown quantity, owing to varying atmospheric conditions. Particularly is this the case where the crushing strains come perpendicular to the grain of the wood. From personal observation, during an experience of 35 years, the writer has come to the conclusion that the safe working load, sidewise on hard pine, should be taken at 100 lbs. per sq. in. in a moist climate, and varying in proportion to the dryness of the climate from that point to 200 lbs. or even 250 lbs. per sq. in. in very dry countries.

In actual practice it is more often strained 500 to 1,000 lbs. per sq. in. During the wet weather the wood becomes soft and crushes together, and then afterwards dries out and in drying out shrinks. The load coming on it holds it down to its smallest dimensions and then the wet weather comes again and swells this out at right angles to the direction of the strains. This alternative shrinking and swelling in time destroys the fiber or strength of the wood. This oversight on the part of the designers is the primary cause of nearly all the failures of wooden trestles.

A secondary consideration should be the facilities for renewal, that is to say, the bridge should be designed with sufficient strength that every piece in each bent can be removed one at a time and another one substituted, without interrupting the traffic over the structure.

Figs. 1-2 are submitted by the writer as general plans for trestles up to or over 100 ft. in height. According to this plan there are no stresses on the side wood great enough to destroy the fiber of the wood. It is so designed that it can be removed piece by piece, and it is intended that all the timber in the structure shall be planed and painted. It is thought that its natural life should be from 25 to 40 years. The intention is to erect this bridge without being painted, but the precaution is taken to interpose a thin sheet of black iron between the intersection of any two pieces of wood throughout. It will be found that where unpainted black iron comes in contact with wood it is a preservative of the wood, and the oxidization of the iron answers the same purpose as an application of paint, so that when a structure is built of comparatively green timber and thin black iron sheets are interposed between two members where they would otherwise come in contact, all the paint is supplied that is necessary at these particular points. Then after the timber has been seasoned in the work the exposed surfaces are painted.

It will be noticed in this plan that there is no direct sill or cap-sills. Instead of these cross-wales are used, which are bolted and spiked on the sides of the posts at each 15 ft. in height, so that the load does not rest on the side wood. This holds at all places with the exception of the cap. Where the span is greater than 15 ft. the load on the cap will be too heavy to be taken up on the ends of the posts, as the posts would crush into the cap under the varying conditions of temperature, moisture, etc. To overcome this difficulty cast steel corbel pieces are introduced on the head of the posts to give a greater bearing surface under the caps. Also on top of the cap where there are steel girders to span from bent to bent a steel casting is used to distribute the load endwise along the cap.

Of course it will be necessary to have permanent foundations for a structure of this kind. If there is a concrete foundation, it might be well to have a cast or rolled steel plate imbedded in the upper portion of the concrete to receive the ends of the posts. If a stone masonry foundation is used, a good coping stone will be suitable to receive the posts by putting a thin sheet of rolled black iron between the posts and the stone.

There is room for a difference of opinion in regard to the fastenings for the different members. Screw bolts are sometimes preferred on account of their adaptability for renewals; however, they do not necessarily prevent the initial movement of the structure, even if that movement is very small. And furthermore the safety of structures fastened with screw bolts is entirely dependent on the care and watchfulness of the bridge repair gang. On the other hand, a spiked fastening effectually prevents initial movements, but in case of renewal of any portion of the structure the removal of a spike generally means the destruction of one of the parts that is fastened by the spike. Therefore the best solution is probably found by bolting the ends of sway braces and cross-wales to the posts, and using a ½ × 8-in. or 10-in. spike also at the ends, then spiking the other portions of these members to the posts. A very large head on the spikes or perhaps what is better still, a pressed washer on the head of the spike, is very desirable.

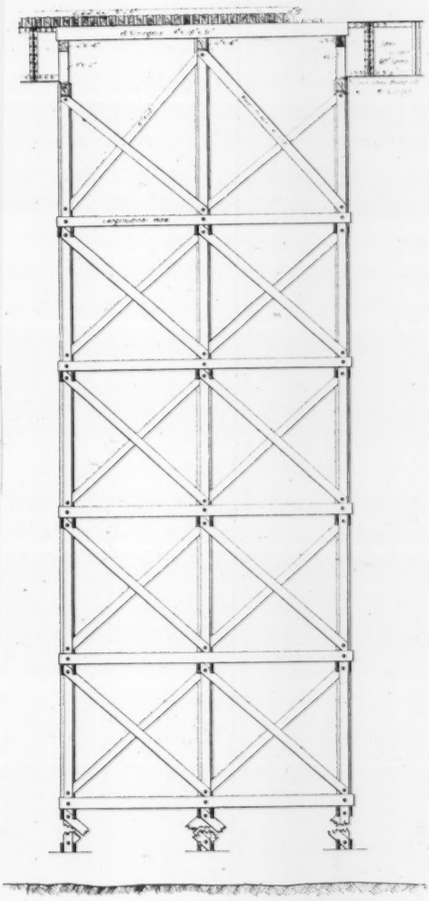

Fig. 2. Suggested Design for Timber Trestle.

Fig. 3 represents a general plan of a wooden trestle as generally built. This style of trestle has a batter of two inches to the foot (one in six). It has intermediate cap-sills and sill. Notwithstanding that this plan has the approval of two great corporations, it is faulty in many details. In the first place it has not sufficient spread to carry the great loads that are expected to go over it. The locomotives weighing over 100 tons and with a high center of gravity, are expected to run over these structures at speeds of 50 miles per hour. The swaying or oscillation of these locomotives on a trestle 100 ft. high will be terrific, owing to the peculiar design of the structures. This swaying motion of the locomotive will have a tendency to crush the posts into the intermediate cap-sills and in a very short time, under high speed, the trestle will have to be renewed. The strains on the side wood of the sills and cap-sills will be sufficient to crush the life out of the wood between the upper and lower posts, owing to the shrinking and swelling of the cap-sills in wet and dry weather.

Because of the rapid increase in the cost of Oregon or Southern pine, or similar hard pines, and to the great increase in the rolling load, it is probable that the day of wooden stringers has already passed, if true economy is sought in

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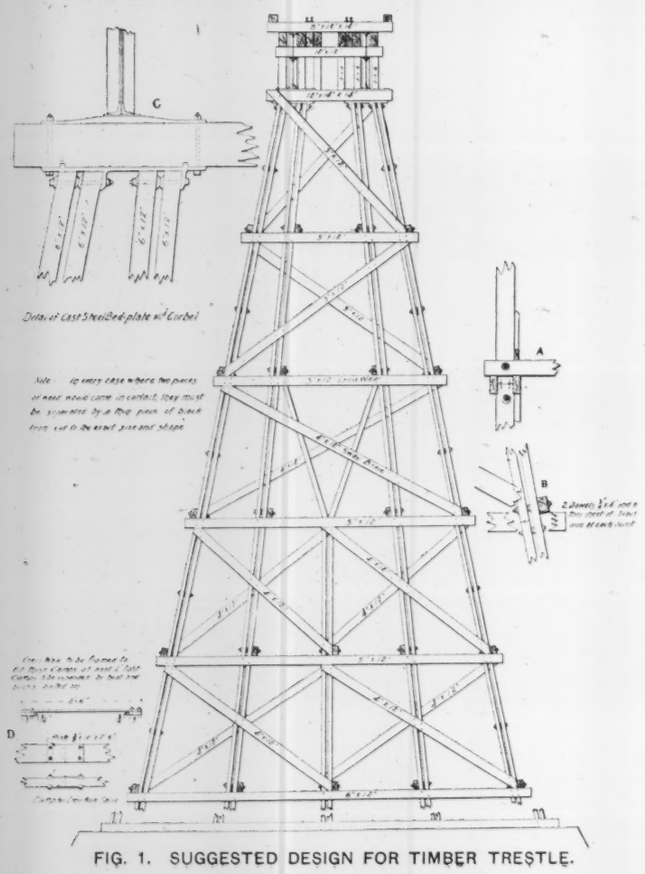
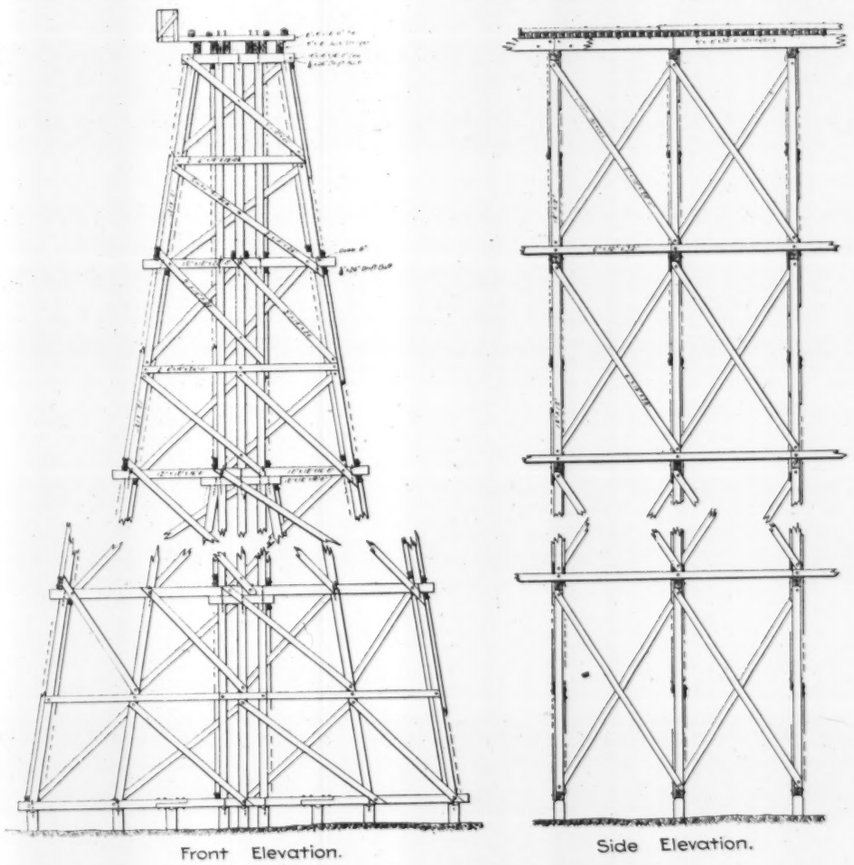


FIG. 1. SUGGESTED DESIGN FOR TIMBER TRESTLE.

the designing of trestles. Steel girders of from 30 to 100 ft. spans will be cheaper than the ordinary 12 to 15-ft. spans of wooden stringers, when we take into account the cost of the bents.

Fig. 1 shows a side view of the proposed bents in the writer's design up to 100 ft. in height. The sizes of the posts are to be 6 × 12 ins., and the longitudinal wales (end view shown in Fig. 1, and shown in detail A) should be 8 × 10 ins., and 32 ft. long. Where two pieces of the posts butt on to each other, two dowels ¾ × 4 ins. are used (see detail A and B), and a piece of black sheet iron of about 24 B. W. gage, cut 6 × 12 ins. and inserted between the ends of the two pieces of posts. Detail C shows a corbel under the cap to which the posts are fastened, and also a cast steel bed plate on which the steel girder rests. Of course there will have to be some means of fastening the steel girder to the bed plate, which is not shown in the detail.

Detail D shows a means of splicing the cross-wales when they become too long to be furnished in the complete length.



Front Elevation. Side Elevation.

FIG. 3. TIMBER TRESTLE AS ORDINARILY DESIGNED.

Fig. 2 shows a side view of tower to carry steel girders with 9 × 12-in. stringers over the tower. The tower braces are to be 6 × 12 ins. throughout until the tower exceeds 100 ft., and the longitudinal wales to be 8 × 10 ins. The ties on this plan are shown 8 × 12 ins., but if greater economy is desired the 9 × 18-in. stringers over the tower might be kept 4 ins. higher and use 8 × 8-in. ties over the towers, always using the 8 × 12-in. ties over the steel girder.

THE HUNTLEY IRRIGATION PROJECT, near Billings, Mont., just completed by the Reclamation Service, is to be opened to settlement on June 26, when 633 farms of 40 to 80 acres each will be awarded by lot. Settlers will be required to pay $4 per acre for the Indian rights and $3 per acre annually for ten years to repay the cost of building the irrigation works. Irrigated land in this section is now selling at $75 to $200 per acre. Full particulars concerning the method of drawing and the qualifications required of entrymen can be obtained by addressing the Register and Receiver of the land office at Billings, Mont., or the Commissioner of the General Land Office, Washington, D. C.

MANGANESE IN CAST IRON.*

By HERBERT E. FIELD.†

The literature in regard to the effect of manganese in cast iron contains many contradictory statements. As is usual in such cases, these statements were correct for the work with which the writers were familiar; the errors come from drawing general conclusions from special experiments. Four years ago, in a paper before your association, I called attention to the confusing statements in regard to carbon in iron. I then cited two opposite statements made by different authorities and showed that both were correct in the limited area of their experiments. Today I wish to reconcile the diverse opinions in regard to manganese in cast iron.

EFFECTS OF MANGANESE ON HARDNESS.

One authority states that manganese hardens iron, while another as confidently asserts that it has a softening influence. Both are correct. There are two conditions which determine the effects of manganese on iron; first, the percentage of sulphur present and second, the amount of manganese. These two conditions are so bound up with one another that it is almost impossible to consider them separately.

Manganese tends to increase the percentage of total carbon; to increase the amount of carbon held in the combined condition; to decrease the sulphur; and to neutralize the effect of the sulphur.

ACTION OF MANGANESE IN INCREASING CARBON.

Manganese itself will hold more carbon in combination or solution than will iron; hence, an increase in the percentage of manganese in an iron tends to increase the carbon. This is especially true in cases where the manganese is added to the ladle as ferro-manganese or spiegel, since the percentage of carbon in these two increases the percentage of carbon in the whole.

When the manganese is charged into the cupola, it acts in two ways to increase the carbon. First, it partially prevents the carbon from being oxidized when the iron passes through the melting zone of the cupola; and second it increases the absorptive power of the iron for carbon, and hence the iron in passing through the incandescent coke will absorb more carbon. The higher the manganese present, the greater will be the amount of carbon so absorbed. In the paper above referred to I pointed out that, other things being equal, the higher the total carbon the softer will be the cast iron. An increase in the manganese, then, tends to soften the iron by increasing the total carbon.

*Read before the American Foundrymen's Association, Philadelphia, May 21.

†Metallurgical Engineer with Mackintosh, Hemphill & Co., Pittsburg, Pa.

ACTION OF MANGANESE IN INCREASING COMBINED CARBON.

The softening tendency, due to the manganese raising the total carbon, is to a certain extent counter-balanced by the action of manganese in forming combined carbon. This combined carbon is not the hardening carbon which gives the intense hardness to quenched steel, but is a definite compound of manganese and carbon. The carbon so united is called carbide-carbon. It is this tendency to form a hardening carbide that has led many to state that manganese hardens cast iron. The hard, gritty nature of some high manganese irons is due to this carbide. We are all familiar with the high manganese pig irons which have a dark, open No. 1 fracture which, even to the expert eye, would be graded as a number 1. When we try to drill this iron, we find that it is almost impracticable to do so with any ordinary drill; and with especially hardened and shaped drills it grinds rather than cuts. This peculiar nature of high manganese iron, which makes it so hard to drill, is due to an innumerable number of small particles of this very hard carbide.

ACTION OF MANGANESE IN DECREASING SULPHUR.

It has long been known that manganese tends to eliminate sulphur from iron in passing through the cupola. This elimination is due to the fact that manganese forms a compound of sulphur which separates from iron at a high temperature. This temperature is above the melting point of iron, and hence the compound passes off into the slag. Sulphur hardens iron and, as manganese tends to eliminate sulphur, it has a decided softening influence upon the iron. This influence, of course, is an indirect one, as it is due to the absence of the sulphur rather than to the presence of the manganese.

There has been considerable discussion in the last few years over the value of manganese ore as an eliminator of sulphur in cupola work. Some German experimenters have stated that a large proportion of sulphur may be removed by the correct use of manganese ore and limestone. Some of our American foundrymen, working on the same lines, have obtained results which are not nearly so convincing. Many reasons have been given for this discrepancy in results, and the prevailing opinion seems to be that the difference is one of temperature. The use of manganese ore in cupola practice is open to several objections; and as high manganese iron can be readily obtained which will introduce the manganese in a very satisfactory manner, the former method is hardly to be recommended for ordinary cupola practice.

NOTES ON PREVIOUS WORK.

A few notes on previous work on this subject might be of interest. A. E. Outerbridge, in a lecture before the Franklin Institute, in 1888, called attention to the remarkable effect of the addition of a small amount of manganese to a ladle of cast iron. Prof. Turner, the English metallurgist, states that manganese eliminates the sulphur as manganese sulphide which floats on the surface of the molten iron, thus forming a part of the slag which collects at the top of the metal.

Walrand melted cast iron high in sulphur in one crucible, and manganese in another crucible, and when the two were poured together a strong odor of burning sulphur was given off. The sulphur was reduced from 0.5 to 0.06 per cent.

Caron's experiments along the same line gave the same result, and he is said to be the first to call attention to this peculiar feature of manganese in its action on sulphur.

J. W. Stead melted 100 parts of ferro-manganese with sulphide of iron in a crucible. The metal produced showed 0.02 per cent. sulphur while the slag analyzed 28 per cent. sulphur and 56 per cent. manganese.

ACTION OF MANGANESE IN NEUTRALIZING THE EFFECT OF SULPHUR.

We have noted that the effects of manganese in eliminating sulphur was due to the formation of a sulphide of manganese which floated to the top of the iron and formed a part of the slag.

Prof. Le Chatelier and Mr. Ziegler first suggested that this effect was produced by the segregation of sulphide of iron at a temperature above the melting point of iron.

EFFECTS OF SULPHUR.

The effects of sulphur on iron are too well known to be discussed here. It makes iron short, brittle, and hard. Excessive amounts make it very weak. These effects of sulphur are due to the fact that when cast iron solidifies, the sulphur is still in a gaseous state and each particle of iron is surrounded by a wall of gaseous sulphur. When the iron cools, the gas solidifies or unites with the surrounding crystals of iron as iron sulphide. In this latter condition, it occupies much less volume than when it was in the gaseous state. This leaves the crystals of iron surrounded by small spaces which, under the microscope, have the appearance of very minute cracks. These cracks give to the iron the

brittle, short property characteristic of high sulphur iron.

The point to be borne in mind in this connection is that the sulphur is in the form of a gas when the iron sets.

Let us go back for a moment and consider the effect when manganese was added to irons high in sulphur. The manganese united with the sulphur and the sulphide of manganese separated at a temperature above the melting point of iron or, in other words, while the iron was in a liquid condition, so that when the iron solidified there would be no sulphur left as a gas to form microscopic cracks, it having already united with the manganese to form sulphide of manganese. The bad properties due to high sulphur would, therefore, be removed. In place of the gaseous sulphur, we have present a sulphide of manganese which will rise to the top of the iron as a slag, provided sufficient time is given for it to do so. If, however, there is not sufficient time, the sulphide of manganese is held in the iron in suspension, in the form of infinitely small, solid particles. These are invisible to the naked eye and do no more harm than so many particles of any solid substance.

There are times, however, when the casting remains liquid for a long time, with the result that this sulphide of manganese will segregate together towards the top of the casting and form bad spots which are difficult to obviate and which are frequently blamed to very different causes.

In spite of the fact that the effects of sulphur on steel and the effects of manganese on sulphur have been known for a considerable time, it has only been within a comparatively short time that this knowledge has been applied in a practical way, or that the facts have been brought together and a lucid explanation given of the cause and effect of the additions of maganese to steels high in sulphur. The credit of bringing this subject again to the attention of metallurgists is due to J. O. Arnold.

While working on a sample of steel rail high in sulphur, furnished by Mr. Brinell and recorded as giving good results, he discovered that instead of the fine, microscopic cracks which would be expected from so high a sulphur percentage, that the steel showed in place threads of what appeared to be slag running lengthwise with the rail. This slag-like material was manganese sulphide and proved to be no more harmful to the rail than the fine threads of slag contained in wrought iron are to that product.

If we apply this to cast iron, we find that the same conditions exist. The effect of manganese on cast iron, which has not previously been explained, under the light of this knowledge becomes clear. The statement that manganese softens iron is readily believed when we appreciate the fact that it forms a compound with the sulphur, thus removing its hardening effect. The strengthening effect of manganese is easily explained when we consider that it removes the small, microscopic cracks caused by the sulphur.

It is very readily proved that manganese does unite with sulphur to form the sulphide of manganese in cast iron. It is not possible to separate it from iron by analysis, but its tendency to rise to the top of the casting gives us a desired opportunity to prove our question.

Chas. H. Risdale gives the analysis of an ingot mold which showed in the top part 1.35% manganese and 0.75% sulphur, while the bottom part of the same mold showed 0.11% sulphur and but 0.54% manganese. An analysis recently sent me of a cyclinder but 24 ins. long and 9 ins. in diameter gave the following analysis for sulphur and manganese at the top and bottom of the cylinder:

	Sulphur.	Manganese.
2 ins. from bottom	0.148%	0.54%
½ in. from top	0.204%	0.66%

It will be noted that this cylinder was but 24 ins. long and that the time taken for it to solidify would be comparatively short; hence, the time allowed for the sulphide of manganese to rise would be of very short duration.

The top of a water pipe cast on end gave sulphur 3.06% and manganese 1.136%, while the bottom end showed but 0.076% sulphur and 0.584% manganese. The top of another pipe gave 0.43% sulphur and 1.79% manganese, but unfortunately no piece from the lower part was saved. These show a simultaneous segregation of manganese and sulphur from molten iron. Inasmuch as manganese would not be expected to segregate by itself, it would appear that this compound must separate and rise to the top of molten cast iron.

The writer considers that this explanation of the effects of manganese on cast iron reconciles the conflicting statements in that direction. It explains the segregation of sulphur and pig iron which has long been known but never explained. It shows why sulphur makes iron weak, and that when united with manganese it has practically no weakening effect on iron. It explains the remarkable effect of small amounts of manganese when added to a ladle of cast iron. It shows why high manganese may cause dirty iron.

OBSERVATIONS TO DETERMINE THE VALUE OF "C" AND "N" AS USED IN THE KUTTER FORMULA.

By J. B. LIPPINCOTT,* M. Am. Soc. C. E.

In Southern California the water supply is decidedly limited, and because of the profits of irrigation, water is very valuable. The "right to use" an "inch" of water, which is a continuous flow of one-fiftieth of a cubic foot per second, sells in Southern California orange districts for $1,000, or at the rate of $50,000 for a flow of a cubic foot per second. One cubic foot per second will yield 646,315 gals. per day, and is adequate to supply 250 acres of developed trees. In addition to this rate, the water consumer or irrigator is expected to pay an annual maintenance charge or rental.

Pipe lines or concrete conduits are ordinarily employed, both for relatively large diversion canals and for the detail distribution of the water to the orchards. Because of the absence of frost in these regions, the methods of lining canals are less elaborate or expensive than would be the case in similar work in the northeastern portion of the country.

Various methods of preventing percolating losses are used. In lining old earthen canals, where the banks are settled and saturated, they are trimmed an inch outside of the neat line, and the bottom and sides tamped and sprayed. A cement plaster is then placed with trowels on this earth to a thickness of an inch, or in some instances grout is poured behind board forms. This is the cheapest form of lining used. While it lasts for several years, cracks develop and are expanded by the growth of plants. Fig. 1 shows a canal of this type at Riverside, California. The lining at the top of the sides is frequently turned over and into the bank in such a way that surface storm waters may pass over the lip into the canal without breaking the lining. A mixture of 1 of cement to 4 of sand is commonly used, and the surface washed with neat cement.

A second method consists of making a gravel concrete, and placing it from 2½ to 3 ins. thick on the sides and bottom. A lining of this character is shown in Figs. 2-3.

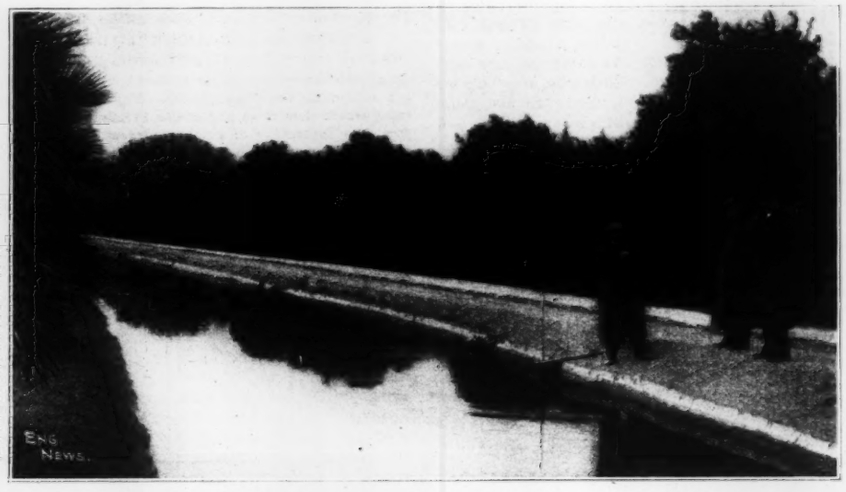


FIG. 1. RIVERSIDE CANAL, NEAR LOS ANGELES, CAL., SHOWING CEMENT MORTAR LINING ½ TO ¾-IN. THICK.

The third method consists of laying up the sides of the canal with boulders or cobbles, from 6 ins. to 18 ins. long, bedded in mortar. These are placed on slopes of 2 on 1. After the side walls are built, the cobble bottom is laid by setting these stones on end, something after the manner of the ordinary cobble street pavement. The work is then pointed up and plastered. Fig. 4 shows this class of construction. This work is done cheaply, and is a permanent form of lining, in some localities standing velocities as high as 15 ft. per sec. without destruction. The cement plaster is scoured off the surface of the bottom, but the cobbles remain in place under these conditions.

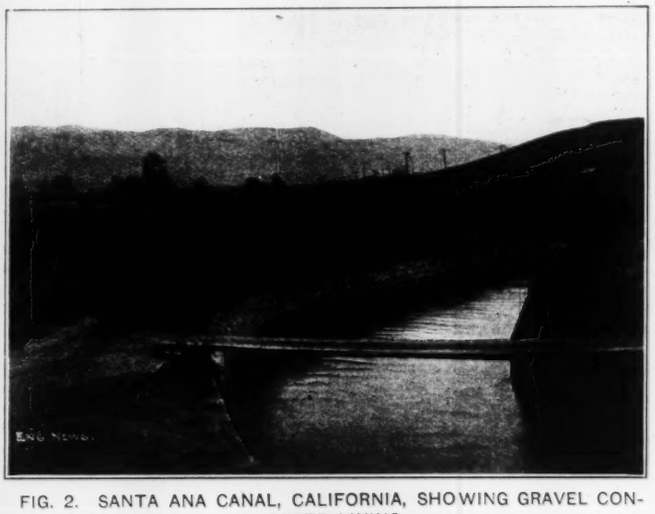


FIG. 2. SANTA ANA CANAL, CALIFORNIA, SHOWING GRAVEL CONCRETE LINING.

Ordinarily the diversions are made from streams having steep mountain gradients, whose drainage basins are granitic, yielding coarse sand, and despite the fact that sand-boxes are put at the head of these canals, it is difficult to prevent some sand from getting into the canal. In canals with flat gradients this results frequently in bars of sand traveling down the channels. The effect is to materially modify the carrying capacity of the canal, both by decreasing its cross-sectional area and rendering the coefficient more unfavorable. Fig. 5 shows the Riverside Canal in this condition after a season's irrigation, and when the water was taken out of the canal for purposes of cleaning.

In Southern California a growth of algae and grass occurs in uncovered canals. There are two varieties, one a long, fibered grass, and the other a lichen-like growth, as is shown in Fig. 4. Canals having this growth on the side and with sand

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in the bottom have their coefficients modified to such an extent that they approach ordinary earthen ditches in carrying capacity. In tunnels or covered conduits, where the light is excluded, these growths do not occur, and consequently the coefficients remain favorable after construction, as far as vegetable growths are concerned. It follows, therefore, that a smaller conduit may be constructed if it is covered, than would be required if uncovered. This saving in size would go a material way in paying for the additional cost of a cover.

The City of Los Angeles, in designing an aqueduct for its new water supply,* has made a study of the working conditions of some of the old lined canals in this locality. These observations are given below, as they may be of some value to the profession.

EXPERIMENTS.

The first four measurements were made by Charles H. Lee, who is now employed by the City of Los Angeles, and who formerly was in the hydrographic branch of the U. S. Geological Survey. The last four experiments were made by D. L. Reaburn, who until recently was connected with the U. S. Reclamation Service and who is now engaged with the city.

The field work consisted of making the measurements necessary to obtain the value of the variables v, r and s. The general method of procedure was to measure the cross-sectional area, discharge and hydraulic grade through a length of channel where the character of the wetted perimeter was as nearly uniform as possible, as regards roughness of original lining, vegetable growths or sedimentation.

With the idea of attaining precision in measurement the following precautions were observed: The cross-sections at the upper and lower end of the course were located on tangents and at points where there were no obstructions in the channels, sudden changes of section, or any other abnormal condition, which might cause irregularity in the direction or velocity of flow. The course was also chosen so as to be free from obstructions and sudden changes of section, but one or more curves in alinement were included. A record was made of the variation of surface level at the upper and lower section throughout the time consumed in making observations to aid in

Fig. 3. Concrete-Lined Storm Ditch, near Riverside, California.

computing a mean discharge for the period. Experiments were not worked up where this variation was marked.

The discharge was measured at the upper section before making observations for the slope and at the lower section after such observations were made. In none of the experiments mentioned below did the measured discharge at these two sections differ by more than 5% due to variation in flow.

Velocity measurements were made with a small Price current meter, with electric recorder. The meter was held at the 1/5 and 4/5 depth points in each vertical, and verticals were spaced by from 1 to 4 ft., depending on the width of section. The period of observation at each point was 50 secs.

Fig. 4. Bear Valley Canal at Redlands, Cal., Boulder Lined and Plastered, Showing Fungus Growth on Sides.

The hydraulic grade was determined where possible by observing, with an engineer's level, surface elevation of water at from one to three points in sections spaced by 100 ft. throughout the length of the course. On curves the sections were spaced closer together and superelevation noted. The areas at these sections were determined by measuring top width of water and elevation of bottom at three or more typical points in the section.

In computations the mean value of v was determined by dividing the mean discharge throughout the period by the mean cross-sectional area for the whole course. The value of r was obtained by averaging the values for all sections. The value of s was obtained by computing the mean of its value for each of the 100-ft. lengths between sections. The value of c was obtained from the formula $c = \frac{v}{\sqrt{rs}}$ and n by use of diagrams and computations prepared by Hering and Trautwine based on Kutter's formula.

EXPERIMENT 1.—This test was made at tunnel No. 15 of the system of tunnels and canals supplying the San Gabriel power plant of the Pacific Light and Power Co. The length of the tunnel is 446 ft. and the grade of its floor 0.00096 ft. per ft. The section is rectangular, 4½-ft. wide and 4 ft. deep, with a semi-circular arch, and finished with a 1 to 3 cement mortar plaster.

There was no vegetable growth in the tunnel which could be felt or seen. The tunnel has been in use for eight years. There is a slight curve at the upper portal. Discharge measurement was made on tangent above the curve. Twenty feet beyond lower portal there was a sharp angle in alinement.

It was impossible to study the cross-section and grade at any points between the portals. On account of the rough character of the topography between tunnel portals and limited time, it was thought best to use the elevations of finished concrete floor at tunnel portals as furnished by the Pacific Light and Power Co. The hydraulic grade was determined by correcting the difference of elevation of concrete at north and south portals by the difference in mean depth of water at these points and dividing by the distance between portals. Measurements of depth were made from a horizontal straight edge. The value of n in the Kutter formula was found to be 0.0127.

EXPERIMENT 2.—This test was made at tunnel No. 23 of same system. Conditions were similar in all respects except for slight curves just below north portal and above south portal, the length of tunnel is 318 ft. and grade of floor 0.00095 ft. per ft.; n here was 0.0115.

EXPERIMENT 3.—Test made at Colton on Riverside Canal on 800-ft. course between S. P. Railway Bridge and Old Mill. The section is trapezoidal with 1 on 1 side slopes, top width 21.5 ft., bottom width 11.5 ft. This canal is uncovered, and is lined with concrete, with a 1 to 3 mortar plaster applied with uniformity. This canal is filled up with fine sand to a depth of from 1.5 to 2.5 ft., and the top layer is subjected to a continual down stream movement by the motion of the water. The plastered sides are covered with a growth of feathery green water grass, many of the individual plants reaching a length of a foot. These float out from the sides and trend down stream in the current. Seventy-five per cent. of the wetted perimeter is shifting and 25% covered with water grass. The conditions under which water flows through this canal are thus equivalent to those of an earthen canal having loose sediment on the bottom and a growth of equatic plants. Two curves, 200 ft. and 100 ft. in length, were included in the course. Fig. 5 indicates these conditions. n was found to be 0.0292.

EXPERIMENT 4.—Test made on a 600-ft. course of Upper Riverside Canal about 1,000 ft. below first Salt Lake Railway crossing, south of Riverside. The section is trapezoidal and uncovered, with side slopes 2 on 1, and bottom width about 8 ft. It is lined with concrete, with a 1 to 3 mortar plaster spread very roughly. Prior to cleaning there was a growth of stringy, green water grass on the sides and bottom, and more or less fine sediment clinging to the roots. The canal was partially cleaned a few days before the measurement was made, and isolated

Fig. 5. Riverside Canal, Showing Sand Deposit Left on Bottom After a Year's Service.

bunches of the grass were left on the bottom. Two curves, 100 ft. and 50 ft. in length, were included in the course. n equaled 0.0212.

This experiment was made in a canal of which a photograph is not available, but the condition of which resembles the condition shown in Fig. 4 of the Redlands Canal, except that it is the type of boulder of construction described pre-

*Engineering News, Jan. 24, 1907.

viously in this article, showing the growth on the sides of the canal.

EXPERIMENTS 5 AND 6.—These were on the main supply conduit for Los Angeles, near the old ostrich farm, several miles north of Los Angeles. It is covered, and has been in use four years. The length of section was 700 ft., being between two manholes. A curve occurred on this section. The wetted perimeter was very smooth, apparently of a 1 to 3 cement mortar. There was no sand, moss or vegetable growth of any kind. Experiment 5 was at the upper and 6 at the lower manhole. The grade of the floor was the same as that of the water surface. The surface is a cement plaster on concrete. The value of n here was 0.0112 and 0.0109.

EXPERIMENT 7.—This was made on the Colton Canal near Colton, California. The length of course was 1,000 ft. on a tangent. The lining was of concrete without plaster. The bottom was free from sand and gravel. The sides and bottom were covered with a thin coat of moss. The canal is uncovered. n equaled 0.01675.

EXPERIMENT 8.—This was made on the Santa Ana Canal in the vicinity of Yorba, California. This conduit is uncovered. The length of section was 1,000 ft.; the lining is of concrete, tamped in behind boards, and not plastered. The bottom was coated with sand and gravel to a depth of several inches. The section was wide and shallow, giving a small value for the hydraulic radius. Fig. 2 is a view taken on this canal, though not at the point of measurement. It indicates the general character of the construction, however. The moss and grass occurred in patches on the sides. n equaled 0.0155.

It would appear from these experiments that a coefficient of 0.012 for n in the Kutter formula would be safe in tunnels or covered concrete conduits with plastered surfaces. For open concrete work, whether plastered or not, where vegetation would occur, the value of n should be increased to 0.016 or 0.018. Where the grades of the conduit are so flat that velocities will be inadequate to keep the channel scoured, and under conditions where silt occurs in the water, a value of $n = 0.020$ or more should probably be used. Experiment 3 shows an extremely bad condition which should be avoided by increasing the sand boxes in the line.

The accompanying table summarizes the results obtained from the experiments.

A board of consulting engineers, consisting of John R. Freeman, Frederic P. Stearns and Jas. D. Schuyler, was engaged by the city of Los Angeles to investigate and report upon the aqueduct which the city proposes to build. They state, relative to the value of the coefficients to be used, as follows:

We suggest the use of the following coefficients in the Kutter formula:

For open masonry conduits of cement or smoothly plastered masonry, $n = 0.018$.

For concrete-lined tunnels, or covered masonry conduits, $n = 0.014$.

For steel pipe with rivet heads and seams projecting on the interior, $n = 0.016$.

For earth canals with bottom as left by dredging, $n = 0.0275$.

ENGINEERS' SALARIES in New York City are at last being raised to a point somewhat commensurate with the responsibilities involved. On May 15 the Board of Estimate and Apportionment, which is the financial controlling body of the city, ordered the following increases in salary of members of the engineering staff: Nelson P. Lewis, Chief Engineer, from $7,500 to $12,000; Arthur S. Tuttle, Assistant Engineer, from $5,000 to $6,000; Harry P. Nichols, Assistant Engineer, from $5,000 to $6,000.

ONE HUNDRED YEARS OF IRON AND STEEL PRODUCTION.*

By SIR HUGH BELL.†

A little more than a hundred yeas ago, when the nineteenth century was still in its salad days, my grandfather, the son of a Cumberland yeoman, came to the Tyne to enter the service of a well-known firm of Newcastle merchants, into which he was shortly after admitted as a partner.

That I, the grandson, occupy by your kindness the distinguished position of your President, and, in that capacity, am called upon to deliver an address this morning, makes it not inappropriate that I should choose as my subject a review of the position of the great trade in which we are engaged, a century after the occurrence which identified the fortunes of my family with the manufacture of iron.

I am only too sensible that it is because of my parentage that the choice of the Council has fallen on me, and that it is as the son of Sir Lowthian Bell that I have been selected to follow a most distinguished series of men who have adorned the chair I now unworthily fill.

Let me then ask you to recall the position of the world in 1807, when the young Thomas Bell entered the firm of Losh & Co., so that we may understand from what platform we started.

The eighteenth century had closed on a world under arms. The titanic struggle which we identify with the name of Napoleon was at its height, and the new century opened amidst the din of battle. The power of the Colossus who was attempting to overstride Europe was undimmed, and rumors of invasion of "the little isle set in the silver sea," which strove to withstand the overwhelming onslaught of his armies, were everywhere current.

The men of that day might well contemplate the future with anxiety bordering on terror. But before the first decade had closed, an event occurred which, to those who had eyes to see, put a term to the dreams of universal dominion, which had dazzled the imagination of the great Corsican. In October, 1805, Trafalgar Bay had witnessed a sight which virtually ended the conflict, though nearly ten years elapsed before the war of the giants ended and Europe was left free to effect the great commercial development which, in one of its aspects, I propose to lay before you.

While Europe was one vast battle-field, and men's energies were being devoted to arms and their capital to armaments, the fertile brains of inventors were busy. Great discoveries were being made, or, what is more important for our purpose, were being turned to useful ends.

Two centuries earlier men had become aware that a great instrument stood ready for those who knew how to use it, but the common opinion which gives to James Watt (1736-1819) the credit of the steam-engine, and forgets Giovanni Branca (1601), Solomon de Caus (1615), the Marquis of Worcester (1663), Denis Papin (1690), and even Thomas Savery (1698), is doing that rough substantial justice which the popular view rarely fails to distribute. Though the great Scotchman was unquestionably aware of the importance of his improvements, which, in fact, made steam the powerful agent we know, even he would be surprised could he see how far his successors have surpassed him in its economical use, and what purposes they have made it serve. For Watt died in 1819, when the steamboat was in its earliest infancy and steam traction on land was hardly begun.

Now, of all the aids we have at our disposal to-day, none is more important than the facility of transport. It has been said that no real improvement in this respect was made from the time when the Romans began to build roads till steam took the place of vital power as a propelling force, and that the Emperors Caracalla and Geta, hurrying from York to claim the Imperial purple in the third century, were no longer in reaching Rome than was Sir Robert Peel in returning from Rome to London to become the Prime Minister of Great Britain in the nineteenth. Yet till the power of bringing together in great masses the mineral resources of the world was attained, the output of iron was limited to those districts where the ore and the fuel chanced to lie in juxtaposition.

The great development of recent times depend entirely on the improvements in transport. What would the founder of the iron works at Dowlais have said had he been told that their prosperity would come to depend not so much on the fact that the iron ore and the coal could be extracted from the same pit as on the accessibility of Cardiff to the Basque Provinces of Spain? And the two things react on one another—without steam transport a highly developed iron trade is impossible; without abundant and cheap iron, steam traction is inconceivable. It is for these reasons that the history of railways is so intimately connected with that of the iron trade.

As is well known the idea of a fixed and rigid path along which the wheels of a wagon should travel is a very old one, but until the end of the eighteenth century it had been but little utilized. It remained for George Stephenson (1781-1848) to show that it was essential to the construction of a road on which the means of traction should be that new power which the genius of Watt and his collaborators had placed at man's disposal. Here, again, the common opinion which connects the name of Stephenson with the great invention and disregards, or at least places in subordinate positions, Murdock, or Trevithick, or Blenkinsopp, or Hedley, does no more than substantial justice. The first quarter of the nineteenth century witnessed the trials and failures which were to end in revolutionizing carriage by land. In 1822 the first railway, in the modern sense of the word, was opened for mineral traffic, while three years later (in September, 1825) the first passenger line, the forerunner of the vast network which now overspreads the civilized world, began operations between Darlington and Stockton.

But to render this possible much more was needed than to invent the locomotive engine or the fixed path. Here, again, we find many names claiming to be inscribed on the roll of fame as entitled to the honor of inventor of the process which was destined to bear its part in the coming revolution. To Henry Cort (1740-1800) we must, in any case, assign a prominent place on the roll, for though we may deny him the title of "father of the iron trade," or even that of the "inventor of puddling," there can be no question that to his ingenuity the industry owes a deep debt. If to him we add John Wilkinson (1728-1808), and the veritable dynasty of Abraham Darbys, of whom the grandfather was born in 1677 and the grandson died in 1791, we have noted the chief of those whose endeavors towards the improvement of processes connected with the iron trade rendered it possible for the inventors of the railroad to make the fixed path of malleable iron produced in great quantities and at reasonable cost. It is not unnatural that the bulk of the names mentioned have been citizens of Great Britain. This country, from its physical configuration, its geological peculiarities and its limited size, presented the most favorable laboratory in which to try experiments. To these circumstances is due the fact that, at the beginning of the last century, one-third of the world's production of pig iron came from these islands, though the total production of the world did not exceed three-quarters of a million tons.

In every case it will be found that the production of iron depended on the proximity of fuel and ore. The iron trade of Sussex died when the exhaustion of the forests removed the fuel. Staffordshire, Scotland, South Wales, indeed every ancient seat of the iron trade in Great Britain, tell the same story, which is true of Sweden, of Russia, and of every country whence, before we entered on the new phase, we drew supplies. For it is interesting to observe that, in the past, England was an importer rather than an exporter of iron. From Sweden, which in 1780 was the chief producer, and from Russia, she brought the metal which her smiths were to fashion into those goods for which she was early to become renowned. But though Sheffield holds and has long held the highest reputation for the excellence of her wares, it is significant that from Spain we derive bilbo as a name for our sword, and from Syria the word damascening to describe the pattern with which it is adorned.

But neither Bilbao nor Damascus bears any part in the history of the iron trade a hundred years ago. We must look to Germany, to France, to Belgium, and to Austria if we would see how the continent of Europe stood at the date we are considering. It will be noted that I do not repeat the names of the two northern countries from which, in earlier days, Great Britain drew her supplies. Sweden and Russia barely count in the developments we are considering. From producing something like one-seventh part of the output of the world in 1830, they have fallen to producing but about one-eighteenth in 1905, though their total outputs have risen from about a quarter of a million tons at the earlier date to over three million tons at the later date.

The great ironmaking districts of Germany which lie in proximity to the Rhine owe their importance to the facilities of transport afforded by the river and by the railways which line its bank.

The works at Essen date from about the time at which my review opens, for the firm of F. Krupp was founded in 1810, but it is not till 1850 that Westphalia begins to play an important part in the history of the trade. By that time, already, it had become possible to transport the ores of the Seig and the Lahn to the coal districts. The discovery of the Bessemer process marks another step in advance. Bessemer compels Westphalia to bring

*Presidential address at the Annual Meeting of the Iron and Steel Institute.

†Rounton Grange, North Allerton, England.

OBSERVATION TO DETERMINE THE VALUE OF c AND n IN KUTTER'S FORMULA.
TABLE OF HYDRAULIC ELEMENTS:

Experiment	Discharge Q	Area of Water section a	Mean Velocity v	Hydraulic mean radius r	Wetted Perimeter p	Hydraulic grade s	Coefficient c	Coefficient of roughness n
No. 1	70.60	14.08	5.01	1.31	10.71	0.00126	123.3	0.0128
No. 2	74.64	15.73	4.74	1.37	11.50	0.00082	141.6	0.0113
No. 3	60.52	30.92	1.96	1.49	20.74	0.00092	52.9	0.0284
No. 4	8.50	6.96	1.22	0.703	9.89	0.00063	58.0	0.0218
No. 5	13.55	5.00	2.71	0.817	6.12	0.00051	132.6	0.0111
No. 6	14.51	5.16	2.81	0.830	6.22	0.00051	136.7	0.0108
No. 7	15.34	6.75	2.27	0.982	6.875	0.0007	86.7	0.0166
No. 8	26.79	10.21	2.62	0.817	12.50	0.00106	89.2	0.0157

ore from Spain. Gilchrist and Thomas restore to the native ores their importance. The basic process marks a great stride, and in 1879 the astonishing development of the German iron trade begins, the production of basic pig iron rising to 8,039,808 tons out of the German pig iron production of 12,293,825 tons in 1906, whilst the output of Bessemer pig iron was only 491,086 tons. Again, it is the possibility of bringing ore from distant countries to the fuel needed to smelt it that this region owes its present position.

The American continent presents the matter in yet clearer terms. I am glad that the limits I have laid down for myself do not call for any account of the position of the trade in that vast country before 1776. The selfish and short-sighted policy which marked our legislation as to our colonial trade makes unpleasant reading for us today. I may pass to 1810, when the make of iron was under 54,000 tons, which compares with 243,851 tons made in Great Britain. In 1840 this had grown to 286,903 tons against Great Britain's 1,396,400 tons. This slow growth continues, the United States not reaching the 1,000,000 tons, to which Great Britain had attained in 1836, till 1864, nor the second million till 1872. By this time, however, the means of transport were improving with extraordinary rapidity. The production pauses between the second and third million for seven years, the reaction of 1876 sending it below 2 millions (1,868,961 tons), jumps from 2¾ millions in 1879 to 3,835,191 tons in 1880, stays for five years between 4 and 5 millions, rushes to 5,683,329 in 1886, and so onwards till in 1905 it has attained 23,360,258 tons out of the world's total of 54,610,269, to which Germany contributes 10,875,061, and Great Britain 9,608,086 tons.

Steam transport by sea and land, steam and electric-driven instruments for dealing with the ships' contents when they arrive at the discharging quay, have alone rendered these extraordinary results possible. The vast distances which so lately as 1890 made a judge as competent as my father doubt the possibility of utilizing the great deposits in the West have been reduced to insignificance, and the coal fields of Pennsylvania placed, commercially speaking, alongside the iron deposits of Lake Superior, from which they are separated by 800 miles of land and water.

But precisely because the distances in Great Britain were small, it was here that the first attempts to annihilate them by mechanical means were made. To this cause we must attribute the growth of the iron trade having in the earlier period been so much more rapid than elsewhere. When the century opened the production of Great Britain did not exceed ¼ million tons. Even thirty years later it was considerably under ¾ million tons, and about half the total production of the world.

By 1830 the improved means of transport had begun to tell, and the progress in the mechanical arts to place better implements in the hands of the ironmasters. The next twenty years raised the British output to 2¼ million tons, out of 4¼ million tons for the world. In the following twenty years Britain more than doubled her output, which in 1870 reached 5¼ million tons out of 10½ for the world. By this time the means of transport first adopted in Great Britain had spread to other countries. The distances separating ore and fuel in America, in Germany, and in France were becoming of less and less importance, and by 1870 the total production of these countries was only about a million tons less than that of Great Britain. Ten years later, the three countries together produced as much as Great Britain. In 1890 she was called upon to yield the premier place to America. In 1903 Germany overtook her, and now, for the year 1905, which is the latest date to which we have complete statistics, the pig-iron output of the world stands as follows:

Country.	Tons.	Percentage of Total.
United States	23,360,258	42.7
Germany and Luxemburg	10,875,061	20.0
United Kingdom	9,608,086	17.6
France	3,076,550	5.5
Russia	2,715,063	5.0
Austria-Hungary	1,540,896	2.8
Belgium	1,310,290	2.4
Sweden	539,437	1.0
Canada	403,449	0.8
Spain	383,100	0.7
Italy	143,079	0.3
Other countries	655,000	1.2
Total	54,610,269	100.0

This enormous quantity may well fill us with surprise. Some fifteen or twenty years ago my father expressed to me alarm at the rapidly increasing output of iron, and doubted whether the powers of consumption of the world were equal to disposing of the huge mass of metal.

That these fears were unfounded the sequel proved.

Within the last twelve months we have seen the world short of iron and clamoring for more, the clamor taking a form which the manufacturers regarded with much complacency, for it resulted in a large increase in price.

And when we ask how the world, which a hundred years ago was content with considerably under a million tons of iron, to-day calls for more when we try to satisfy it with upwards of 50 million tons, the answer is not far to seek. The ingenuity of man was not exhausted when our grandfathers invented railways and steamships. Iron gives place to steel. The puddling furnace, having served its purpose, is tossed aside for the Bessemer converter. An instrument with which the arduous labor of several men produced in twenty-four hours about 2½ tons of malleable iron, is rejected for one in which the forces of nature, guided by human skill, gives us 30 tons of steel in twenty minutes. Iron, but sparingly used when the century opened, is demanded in continually increasing quantities to-day. The iron trade, responding to the call of the world, seeks new methods for producing still better results, and would seem to be about to reject the Bessemer converter for the open-hearth furnace. The remarkable invention of the regenerative furnace made fifty years ago is being continually perfected. Even now the great improvement of a continuous instead of an intermittent process is touched.

The men who stood on the threshold of the nineteenth century would have been filled with astonishment could they have foreseen the changes it was to bring, giving us a world in which time and space are all but excluded from our calculations. A telegram with which we greet a distant friend in America reaches his hand hours before the sun has traveled westward to mark there the same time as it marked here when our message was dispatched. Jules Verne, by the exercise of his imaginative art, told us how with great good fortune his hero encircled the world in eighty days. With no trouble to ourselves beyond taking a ticket from a tourist agency, we could travel westwards from London till we reached this city again from the East in a day or two more than half that time.

But let me picture to you one who, one hundred years ago, should have said to the most skilled and far-sighted man of that day, "Within a century from now corn grown on the western slopes of the Rocky Mountains will be conveyed by steam along an iron road to the sea coast, borne over the sea in a ship made of iron and propelled by steam, and sold in the London market cheaper than it can be grown in Essex." Not one of his anticipations would have been thought within the range of the barest possibility.

Beyond doubt we, who stand on the threshold of the twentieth century, may look forward to changes as great and far-reaching before the next hundred years are run out. New forces are again being placed within our reach. The ultimate possibilities of the electric current are not yet within sight, though, with the eyes of faith, we may guess at them. It may well be that the steam-engine will be as obsolete as the horse gin before the twentieth gives place to the twenty-first century, and that the new machine will be in truth the heat-engine towards which the first experimenters worked. Our views of the constitution of matter are in a state of flux, and though the highly abstruse questions involved in this may seem far removed from these technical questions which chiefly occupy us, they are no more remote than may have seemed the discovery by Oersted of the deflection of the magnetic needle by an electric current. Yet that discovery contained the germ of the electric telegraph.

And if I to-day look forward, as I picture that other man to have done a century since, what form might my guess of the future take? How in a hundred years will the great swiftly-gliding ship of those days be propelled? With little, or mayhap with no machinery on board, with barely any crew she speeds on her way drawn by the electric force generated at Niagara, and transmitted over the Atlantic by wireless telegraphy. She crosses to New York, takes her cargo, and returns as she came.

Strange as my forecast may seem, it is no more incredible than what has happened since 1807. The things which to us are commonplaces would have been deemed impossibilities by our forefathers.

The world moves on in a succession of dreams and their fulfilment. The wild imaginings of one age become the splendid realities of the next, for

". . . all experience is an arch wherethro'
Gleams that untravel'd world whose margin fades
For ever and for ever when I move."

STEEL BOX CARS are being built by the Carnegie Steel Co. for the Universal Portland Cement Co., and will, it is said, weigh about 3,000 lbs. less than wooden cars of the same size and capacity. The Union Pacific Ry. has built at its Omaha shops two 40-ft. steel box cars of 50 tons capacity, weighing 38,450 lbs., of which the body represents 25,350 lbs. The cubic capacity is 2,770 cu. ft. The standard 40-ft. wooden box car of this road weighs 42,200 lbs. There is a single center sill, consisting of a 15-in. I-beam, between the bolsters, but from each bolster to the end sill there are two 12-in. channels forming draft sills. The side sills are of fish-belly pattern, with inside chord angles, the side sheets forming the web. Between the center sills and side sills is a herring-bone framing of 3½ × 5-in. angle. The posts are tees and angles, and angles form the carlines. Diagonal braces of two 2½ × 5½-in. angles extend from the top corners of the door openings to the ends of the bolsters, and there is also a diagonal member in each end panel. The sheathing is of No. 11 steel plate, with No. 14 for the doors and 1/16-in. for the roof. This is placed inside of the framing, so as to give a smooth interior for convenience in shipping grain.

A RECORDING MACHINE FOR DYNAMOMETER TESTS ON RAILWAY TRAINS.

The Railway Department of the International Correspondence Schools put in service about a year ago a dynamometer and test car, with a hydraulic or oil dynamometer to test the train resistance, and a number of appliances to make records of other matters connected with the movement of trains; the speed, time, distance, steam pressure, amount of coal fired, water used, brake applications and curvature of track.

An illustrated paper on this car has recently been presented before the St. Louis Railway Club by Mr. Frank McManamy, of the International Correspondence Schools, and from that paper and information furnished by Mr. W. N. Mitchell, General Manager of the Railway Department of the Schools, the following article has been prepared.

DESCRIPTION OF MACHINE.

The photographs from which the accompanying views were taken show the machine before it was placed in the car, hence the pipe connections near the floor are not all coupled up. In Fig. 1, at the lower left hand corner, is a small square box that contains a set of automatic reversing gears. On the rear axle of the car is a 60 to 1 worm gear from which the shaft comes up through the floor of the car to this reversing box and drives the gears of the recording machine moving the paper rolls. The shaft and gear box are both constructed with a view of taking care of any movement whatever that a car may make. The shaft has both slip and universal joints, to protect it from injuries due to any relative motion between the car body and trucks. The automatic reversing gear protects the machine from any injury from a change in direction in the movement of the car, as it always reverses on the first impulse given it.

This gear box was placed to be in the center of the car and the machine was placed so as to leave as much room as possible to get around it, therefore the power must be brought from the gear box to the machine gears proper through a horizontal shaft. This shaft ends in a miter gear which drives another shaft having on it a slotted sleeve, the slot sliding over a feather key. This sleeve may be shifted up or down by a lever, and as this sleeve carries three gears, meshing with three other gears, there are three paper speeds, ½, 1 and 3 in. to the mile. This shaft finally drives the calendar roll and with the aid of the rubber friction roll pulls the paper through the machine.

In order to have a good record of the general performance and work done during stops it is necessary to keep the paper moving while the train is standing. This is done by the use of an electric magnet which pulls up a ratchet every 5 seconds. This magnet drive is called a time drive, and gives the paper a travel of ½-in. per minute. The shaft through the center of the calendar roll carries 3 gear wheels, which are flat against one another, the outside wheels being free to turn on the shaft, while the middle wheel is feathered to the shaft. The end wheels carry spring pawls, which engage the middle wheel. The idea of this arrangement is to make the two drives entirely independent, one drive in use, the other entirely idle.

The record is made by pens, actuated as shown hereafter, marking on the paper as it is driven through the rolls. The first or lowest record on the sheet is the station marker. In the upper left-hand corner of Fig. 3 is a group of electro magnets, the first two of which make the station records. The observer riding on the engine makes and breaks the circuit through these two every time a station is passed or a stop or start is made. When the train is in a siding the circuit through the first is held closed, thus making a quarter inch offset in the station line. In the same way the second magnet is used for a half-inch offset, to show train backing up. Another magnet in this set is used to mark miles or parts of miles. The circuit through this magnet is closed by a finger on the shaft coming out of the gear box, which is geared to turn ten times to one mile, so that 1/10-mile, ½-mile or 1-mile marks can be made by the use of the proper

gear between the shaft and the finger making the contact.

A little lower down is another magnet pulling every 5 seconds a ratchet, which works into a little gear-wheel on the same shaft. The teeth of this gear-wheel are really cam curves which work against the block on the end of the time pen rod lever. Every move of this wheel causes one of these teeth to set the time line pen over 1/10-in., and the teeth are of such a length and arrangement as to cause a dropping back of the pen every half-minute. The twentieth space between the teeth is a little deeper than the rest. That makes a longer line for the 10-minute mark than for the half-minute mark, so there is on the time line 5-second, 30-second and 10-minute spaces, distinctly indicated.

The electrical clock or commutator switch is an ordinary clock, having in it a 5-second make and break contact, something like the striking arrangement of an ordinary clock. This contact being made, the circuit is closed through a magnet on the commutator switch proper. This magnet pulls a stop pawl out of a wheel slot and the shaft or commutator revolves once, the stop dropping back into its slot on the first revolution. The revolving shaft has on it three separate commutators of one segment each, arranged in relative positions on the shaft so as to do work which will be spoken of later in describing the speed recording device.

The mechanical idea of the speed recorder is very simple. A cam is geared to the wheels of the car in such a way as to drive a block out a certain distance for every speed in miles per hour, and allowing this block to return every 4½ seconds. It is the work of the commutator switch to release this block and stop the cam. The cam, instead of being fixed on a gear shaft, is carried on the armature of a circular magnetic clutch, the clutch being geared into the machine gears, thence, of course, to the axle.

On the commutator switch the segment for the circuit through this clutch is so placed on the shaft that the current goes through the clutch every 4½ seconds; then as the shaft revolves the current is opened for ½ second, freeing the cam and allowing it to turn on the face of the clutch so it is pulled back to zero by a return spring and then starting its movement anew every 5 seconds. This makes the speed record correct to 5-second intervals. To prevent the pin or block which works against the cam from returning clear to zero it is held by a brake. This brake is held down by a spring all the time except for an instant, but on the commutator switch there is one segment so placed that just at the instant before the speed cam is released there is a circuit closed through a magnet which lifts the brake off the block and leaves it free, only long enough, however, to be moved into the proper connection by the curve of the cam, so that we have a continuous line with very little irregularity for a speed curve.

The piping coming from out of the machine towards the floor is from the hydraulic dynamometer cylinder, which registers the pressure on oil by indicator cylinders on the machine. There are also air pipe connections showing the pressure in the brake cylinder and train pipe, as well as a steam pipe from the boiler of the locomotive to the indicator on the machine.

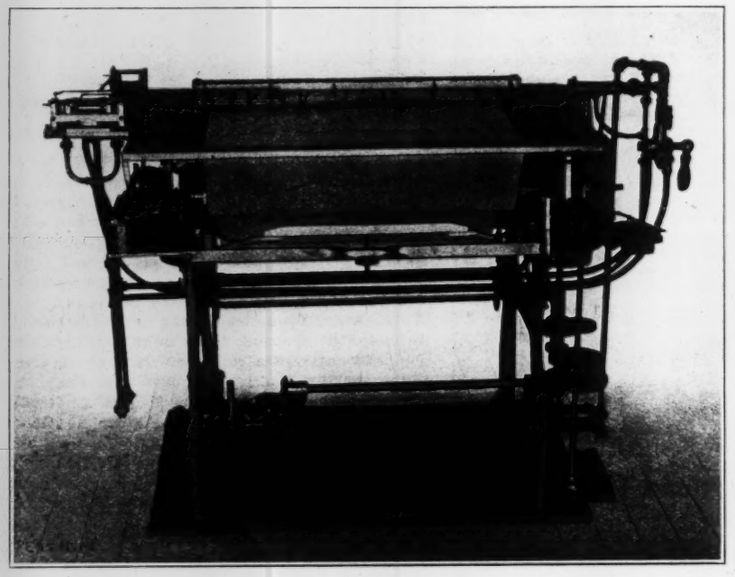


FIG. 1. FRONT VIEW

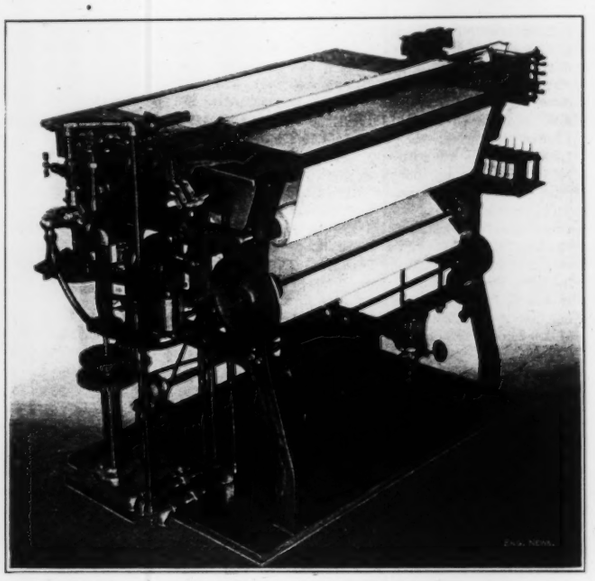


FIG. 2. RIGHT SIDE VIEW.

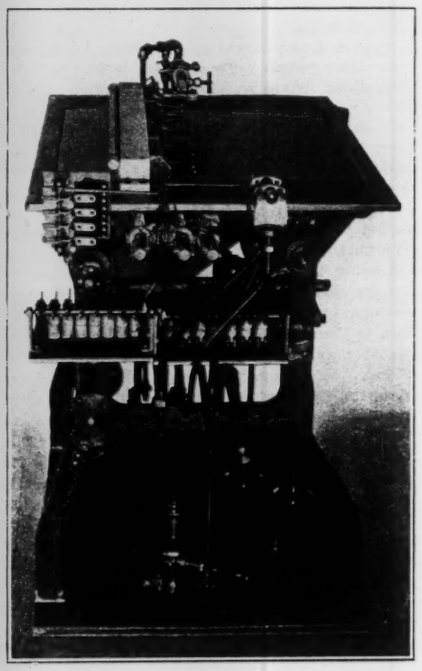


FIG. 3. LEFT SIDE VIEW.

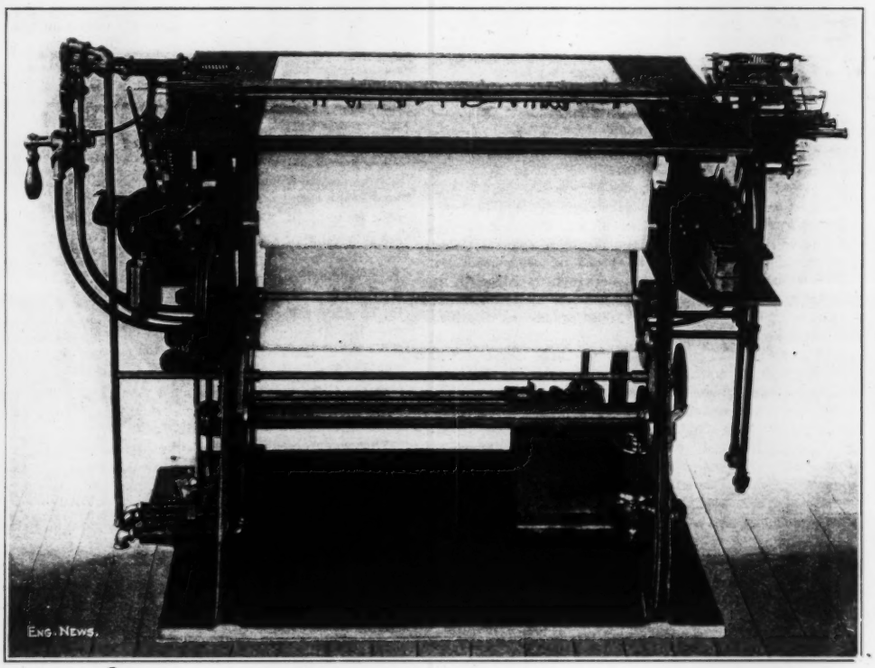


FIG. 4. REAR VIEW.

RECORDING MACHINE FOR DYNAMOMETER TESTS ON RAILWAY TRAINS.

There are also two magnets used in recording throttle and reverse lever positions. Each of these magnets makes one stop in its line and records the position automatically. The wires representing the circuits of these magnets are carried to the engine through a cable. Here they are connected to a box, having a circular row of segments, or contact pieces, in it, each magnet being connected on one side to its respective segment, and on the other side to a common return wire for the whole set. This common wire is connected to a single segment, which is on the face of a flat spool traveling over the circular segments in the box. A string or fine chain wrapped on this spool is fastened to the throttle or reverse lever, as the case may be, and any movement of the lever moves the contact around the circle of segments, thus closing the circuits of the magnets, which the segments represent, and indicating the relative positions of the levers.

The coal record is made by the observer in the cab with a push button. Every time a shovel of coal is put into the fire box a counter is pushed down. This counter constitutes the make and break of the circuit. By counting the record on the chart and reading the counter number this is a mileage line, showing the distance in half-mile spaces, but which can be arranged to show tenths of miles if desired.

Next to the mileage line is the line recording the amount of coal fired. Each mark on this line indicates a scoop of coal put into the fire box, and by counting the number of scoops in each group a complete record of the firing is made. Between times of putting in fires a few scoops of coal are weighed and a record made of the weight, so that the weight of the average scoop can be thus obtained.

Next is the speed line, the straight line being the zero or datum line, and the distance between that and the curve line indicates the speed of the train. Above the datum line comes a straight line which indicates the schedule speed of the train between stations, and it will be noted that this schedule speed changes at each station. This schedule speed line shows at a glance whether the train is losing or making up time. If necessary to know the time consumed in making a stop at any particular station, by laying a rule across the chart at the point where the speed curve begins to go down, and checking the time line from that point to the point where the stop

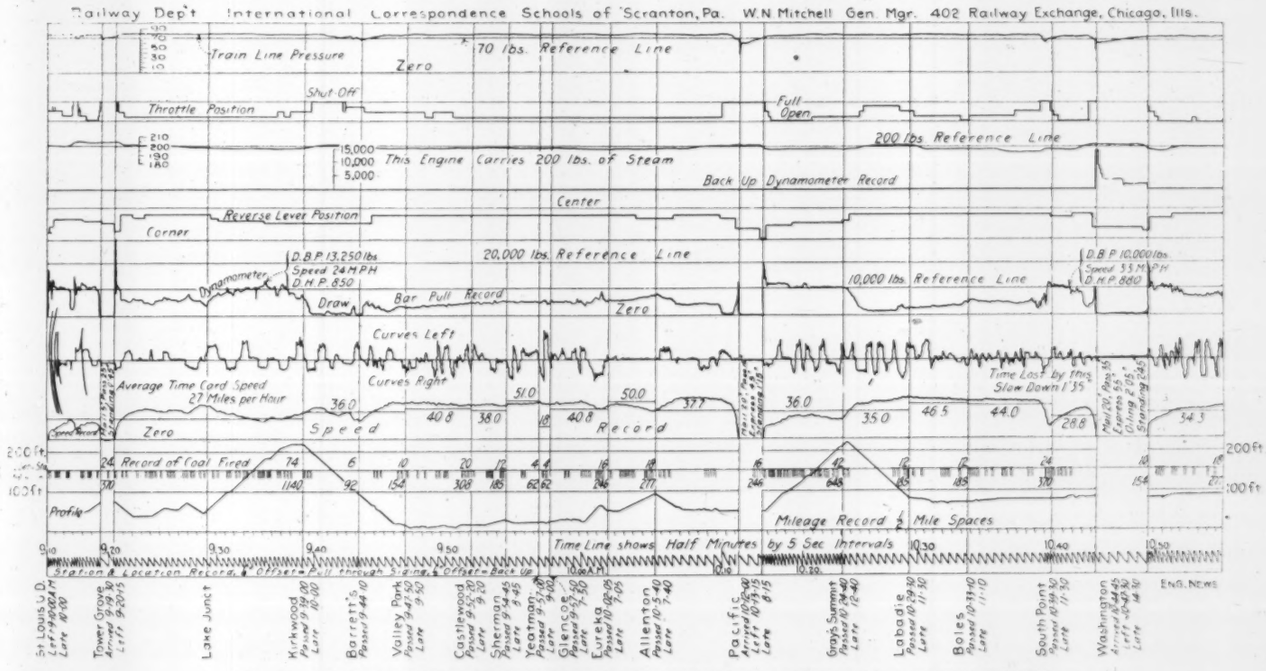


FIG. 5. RECORD MADE BY MACHINE FOR DYNAMOMETER TESTS ON RAILWAY TRAINS.
(In use by the Railway Department of the International Correspondence Schools, Scranton, Pa.)

there is a double check on the record of fuel consumed. With this same principle of a make and break in an electrical circuit through magnets on the machine, almost any record that different occasions may call for can be made, such as smoke record, swing of the fire box door, shaking of grates, proportion of time injectors are working, and it would also be comparatively easy to make a record of steam chest pressure or smoke box vacuum.

RECORD MADE BY DYNAMOMETER.

The chart in Fig. 5, with the accompanying table, shows the record of a run made on the Missouri Pacific Railway, using an axle drive, with the paper travel ½ in. per mile. The description of this record will begin with the bottom line, which is the station location line. When leaving terminals or passing stations a short mark at right angles with the station line is made, indicating the exact time of leaving the terminal or passing the station. At all stops both arrival and departure marks are made, showing the exact time the train is standing.

Next above this comes the time line which keeps a record of the time in 5-second, 30-second and 10-minute intervals, in a sort of sawtooth record, the distance between the teeth indicating the speed at which the train moves. Next above is made, the exact time consumed in making the stop will be given.

Next comes a line showing the curvature of the track, both right and left, the pen making this record being operated by the truck. By comparing this record with the drawbar pull the increase in train resistance on curves is shown.

Next comes the record of the drawbar pull. The lower straight line is the zero line and the next two above it indicate 10,000 and 20,000 lbs. pull, respectively.

The next record indicates the position of the reverse lever while working in the forward motion, the top line showing where the record would be if the lever was on the center, and the bottom line indicating the corner. The variations in the record line show the position of the lever between those two points. The next record shows the position of the throttle for ¼, ½, ¾ and full opening. Next comes the steam pressure line, the line indicating the maximum boiler pressure and the curve the actual pressure. Above that at the top is a line indicating the train pipe pressure, showing each application of the brake and the amount of reduction.

This car has been in service long enough to have been thoroughly tested out as far as accuracy and utility are concerned. It has been in steady service and can be rented on moderate terms by any railroad company who wishes to use it, together with the services of an expert to manage the machines and check up the records. The observers for the engine and other duties around the machine are usually furnished from the ranks of the skilled special apprentices in the service of the company.

A TAR MACADAM ROAD AT MANKATO, MINN.*

By R. E. BROWN.†

This section of the city streets had always been hard to keep in good condition, on account of a grade of about 8 to 9% and a soil consisting of yellow clay, with springs in certain portions at almost all seasons of the year. After the grade was established and the cement curb and gutter was in place, we took off 6 ins. from the surface of the roadway and put on 5 ins. of crushed limestone, broken up in pieces from 1.5 to 2 ins. in size and rolled this thoroughly with a ten-ton steam roller, until it was down to the required thickness and grade. It was then sprinkled with boiling coal tar, using large sprinkling cans for this purpose. We then took small crushed limestone, about 1 in. screen and mixed it dry with common gravel, putting one wheelbarrow of gravel with three wheelbarrows of crushed limestone, saturating it thoroughly with boiling tar and mixing it on a movable platform and then sprinkling it over the roadbed about 2 ins. thick. The ten-ton roller had in the meantime brought the other coarser work down to about 4 ins. in thickness. We then used hand-tampers and made this layer even and solid and then sprinkled dry cement over the whole surface and rolled it with one-ton roller. The cement used made it possible to roll this last layer at once while hot and it did not stick at all to the roller in treating it in this way. We then put on about ½-in. of gravel and sand and re-rolled it to shape and place with the smaller roller. We attached a pulley at the upper end of the street and two men operated the roller down the hill, while two horses brought the roller up to the top each time, but were not allowed to go on the finished road, only on the boulevard strip at the side of roadway.

This spring the tarred macadam street is the best we have in our city, excepting the asphalt and brick pavements which we have in a portion of our business section and which, on account of their cost, are prohibitive for general purposes.

The cost of this tar macadam is less than $1 per front foot on a 30-ft. street. This first block of tar macadam was laid on this heavy grade, because a common macadam on that section was a complete failure on account of each heavy rain cutting into it, carrying the paving away to below the gravel and soil and leaving the rock exposed. With tar as a binder, all this is impossible.

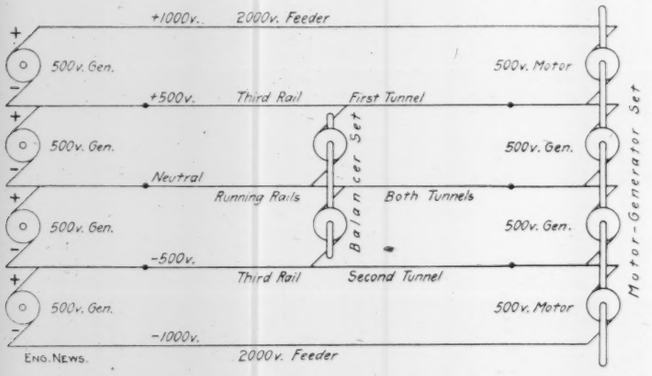
*Extracts from a letter in the Progressive Age, issue of May 15, 1907.
†Mankato Gas and Electric Light Co.

EXTENSION OF THE CITY & SOUTH LONDON RY. CO.'S SUBWAY IN LONDON, ENGLAND.*

One of the most important additions to the London subway service since 1890 has been recently completed by the City & South London Ry. Co., pioneers among the underground tube railways of London. This extension affords for the first time direct railway connection between three of the principal railway stations north of the Thames and two of the principal stations south of the river. The length of the new line is about 1½ miles. A description of the older lines of this company was given in our issue of March 21, in connection with a general article on the rapid-transit facilities of London.

The operating equipment of the new line is unique, in that it retains electric locomotives instead of adopting motor cars with multiple unit control, such as are used on the other London subways. However, the old system of direct-driven locomotive axles has been replaced by geared motors. All-steel coaches have been added to the rolling stock for that part of the new equipment made necessary by this recent extension.

The system of electrical supply follows the original plans of this company as outlined by Mr. P. V. McMahon in the Journal of the Institute of Electrical Engineers for April, 1904. It is fundamentally a five-wire arrangement, having 2,000 volts between principal feeders. The running rails constitute the central wire of the system, while the third rail of one tunnel is connected to the intermediate positive conductor, and the third rail of the other tunnel is connected to the intermediate negative conductor.



SIMPLIFIED DIAGRAM OF SYSTEM OF ELECTRICAL SUPPLY; CITY & SO. LONDON RY. CO.

This is shown in the diagram herewith. Thus the locomotives are supplied with current at 500 volts, although the third rail is of different polarity in each of the new tunnels.

At the end of the line where the tunnels loop together, it is necessary to pass from one side of the system to the other, and, to do so without danger of causing a 1,000-volt short circuit. This is done by a 30-ft. wooden break in the third rail. The locomotives run over the break by momentum, but to supply the train lights it was found advisable to fasten a small conductor to the wooden break of such a length that the actual electrical gap is reduced to 16 ft. This supplementary conductor is connected to one third rail through a fuse, so that should the engine-runner forget to shut off the power current, the fuse would blow before harm was done. In spite of the rather old-fashioned equipment, the operating expenses of the City & South London line have been kept as low as those of any London railway using alternating current transmission and motor cars. This is of interest in view of the recent statement of Mr. Frank J. Sprague, Past Pres. A. I. E. E., that were the Pennsylvania Railroad called on to-day to substitute electric traction for main line interurban service, it could best be done by the higher voltage, direct current systems.

*Abstracted in part, from "Electrical Engineering," London, April 11, 1907.

CONCRETE AND REINFORCED CONCRETE CONSTRUCTION FROM THE FIRE PROTECTION VIEW.*

Ever since this Committee was appointed, it has been investigating the general subject of cement and concrete as used in various types of building construction, with a view to determining their value as a fire resistive material, and endeavoring to formulate a standard specification for their use which should be both safe and commercially practicable. This has been no easy task since the real nature of cement itself, and its action under varying conditions when combined with other materials, have been so little known, and have been the subject of such wide difference of opinion between various authorities, and, furthermore, there has been so very little experience in actual fire with buildings of any sort of concrete construction. However, the past few years have marked rapid progress in the concrete building art, and while it is still far from perfection, and high authorities still differ on some technical points, they are getting nearer together on the fundamental features, and we believe are sufficiently agreed on such points as pertain directly to fire resistance to warrant the recommendation, in rather general terms, of a specification for reinforced concrete building construction.

The National Board of Fire Underwriters, through its Committee on Building Construction, has recently issued a revised edition of a Model Building Code, and is urging its adoption by municipalities throughout the country. The section (No. 110) of this Code referring to reinforced concrete construction has been somewhat revised and is submitted herewith, as being as practical and acceptable a specification as the present state of the art will permit. It is, of course, expected that in time experience will necessitate modification or amplification of this standard, but your Committee is unable to see any probability of sufficiently important developments in the near future, to warrant further delay in the promulgation of such rules as experience has already proven wise.

There are three general features of this specification which we feel warrant especial emphasis; features which experiences of the past year or two particularly have amply proven as being those always likely to need the most careful consideration on the part of all concerned, viz:

DESIGN OF REINFORCEMENT.—While this is a point on which there is more difference of opinion between engineers than any other, the specifications here outlined have been drawn by eminent authorities, and we believe will produce a building safe from all points of view, and will meet with as nearly universal approval as any specification which might be devised at present, and at the same time are sufficiently broad to accommodate the special features of many so-called "systems."

We would also call attention to a point omitted in the specification, namely: that the design of such buildings should be undertaken only by engineers of special training and experience along this line. Some advertisements of patented systems of reinforcement may seem to indicate that the erection of a building using some particular design is easy, and does not require much experience, etc., but the fact is, there are many intricate questions which cannot be solved by the aid of advertising text books or stereotyped specifications, and we would urge that the design of a building of this type should only be entrusted to trained engineers of recognized ability in this particular direction, just as would be the case if a steel frame building or bridge of equal importance was under consideration.

INSULATION OF STEEL REINFORCEMENT.—The result of tests we still believe indicate the necessity of better insulation than the one-inch thickness which present practice generally provides. We have no further comment to make on the basis of experimental tests, but practical experience since that time, particularly in the San Francisco fire, has amply demonstrated the need of heavier insulation.

There were 31 buildings involved in this great conflagration having more or less concrete construction. In most of them the concrete was used only for floor panels between steel beams, and was made, in some cases, of cinders, but chiefly of stone.

After the fire some of these floors were found in fairly good condition; that is, in cases where steel columns and girders supporting them had been sufficiently insulated from heat to stand up. In most cases, however, the protection on columns and girders was so thin, or frail, or of such poor material, that the steel members either collapsed or buckled so badly as to ruin many of the floor slabs. There were no buildings involved having reinforced concrete columns, but there were several which contained beams and girders of reinforced concrete, and from these we may draw valuable lessons on this question of the insulation of steel.

1. The Young or Seller Building, corner Market and Spear Streets, was a five-story structure with brick walls and steel frame with intermediate floor beams of concrete, having a most primitive type of reinforcement, which though probably not in favor anywhere at the present time, serves as an extreme illustration of the point under discussion. These beams were in effect reinforcing webs projecting from the lower face of the floor slabs and consisted of a flat rolled steel strap about 5 ins. wide by ⅝-in. thick, with each end hooked over the upper flange of steel girders and bowed downward so that its center hung about 8 ins. below the lower face of the slab. On the top of this suspender strap was formed the concrete beam or web. There being no protection for the bottom or edges of the steel strap, of course, it was quickly heated up to a point where it failed to carry its load, and the floor either collapsed or was badly deformed, the amount of damage depending upon the amount of heat in different localities.

The Hall of Justice was of practically the same construction and suffered the same damage to a somewhat less degree, owing to the protection of suspended metal lath and plaster ceilings. Construction of this type is probably a thing of the past, and would not be recognized as worthy of the term reinforced concrete. It is cited here, however, to illustrate the point that steel reinforcement needs adequate insulation.

2. The Johnson Building, corner of Minna and First Streets, a five-story brick walled structure, occupied for harness and leather goods store. In this case the columns and main girders were of steel, but there were numerous intermediate floor beams of so-called reinforced concrete, although the reinforcement in this particular case seems to have been hardly worthy of the name. Instead of a well-selected type of steel bar made for the purpose, it seems that a miscellaneous collection of old, twisted wire and various sized rods were used, which, even if in good condition, were not heavy enough to carry their loads with safety, and, furthermore, were located not over 1 in. from the bottom face of the beams.

The contents of this building undoubtedly produced a hot fire, though not at all abnormal for a mercantile house, and the result was the collapse of a portion of the building, and such a serious cracking and bending of most of the beams and floors as to render them valueless for further use. Bad design and improper insulation both contributed to the serious failure in this case.

3. Pacific States Telephone and Telegraph Co.'s main office building, on Bush Street. A brick walled steel frame building, with flat gravel concrete floor slabs between beams. In the roof construction were a number of small-sized intermediate beams of reinforced concrete, having their steel members imbedded apparently about 1 in. from the lower surface. The upper stories of the building were filled with supplies of various kinds, and the heat was naturally severe in these upper stories, including the one immediately under the roof. These concrete beams were badly deflected, one of them failing entirely. In this case the steel columns throughout the building were insulated by 3 ins. of stone concrete, and, to the best of our knowledge, were not themselves injured, although the concrete covering was naturally weakened for some distance from the surface and will doubtless have to be replaced.

CAREFUL WORKMANSHIP.—The necessity for improvement along this line has long been recognized, and here, at least, there is little possibility of disagreement as to what is needed. The experiences of this past year have given additional proof of the gross carelessness and incompetence which have prevailed in many important works. There have been several instances of the collapse of large and expensive buildings in course of construction which have in every case been traced to neglect of well-known rules of safety. For instance, in one case the direct superintendence of the work was left to cheap help, who did not appreciate the necessity for accurate and careful workmanship, and the result was too little cement, too little water, or improper mixing, which allowed the collapse of the building wall before it was half up. In several cases the concrete has been allowed to freeze while under construction, and, naturally, it fell down on removal of forms.

The wooden molds or forms have not been properly cleaned out before receiving the concrete, with the result that shavings, blocks of wood and other refuse have been embedded in concrete in such a way as to make a vital weakness at important points in the building. Certain steel reinforcing rods, called for by plans, have been either misplaced or omitted entirely, which together with unsafe design of original plans, caused one

*Report of the Committee on "Cement for Building Construction" of the National Fire Protection Association, presented at the Eleventh Annual Meeting, New York City, May 22 to 24. E. T. Cairns, Chairman, 76 William St., N. Y. City.

very serious collapse. Concrete foundations have been laid in mud, with the natural result that they failed to support the superstructures. Blocks of wood, for the purpose of holding fixtures, have been found purposely cast in the bottom of beams in such a way as to directly expose the steel reinforcement when the said block was burned or knocked out.

While calling attention to the unusual number of such failures occurring in the last year, it is only fair to admit that the number of buildings erected is also very much greater than in any previous year, and the proportion of failures may not be so much larger. Moreover, it is very encouraging to notice the extensive discussion which these failures have provoked in engineering journals, and the widespread condemnation by the public in general of the methods which have allowed these accidents, all of which must naturally tend to prevent, in some measure, the repetition of the errors in future by making it a commercial necessity for concrete builders to regulate this personal element which is especially prominent in concrete work, in order to insure a sufficient degree of public confidence to secure permanence of their industry.

The section of the Building Code submitted refers especially to structures of reinforced concrete throughout, but the rules are also generally applicable to concrete floors and roofs between steel beams and girders, as far as they relate to preparation and handling of the concrete itself. In such steel framed buildings concrete may safely be used for floor and roof slabs and for insulation of steel work, provided it is of the specified quality, is securely attached to the steel member by steel rods, expanded metal or woven wire and is thick enough to protect against penetration of heat, which thickness in the opinion of this Committee should be not less than 4 ins. on all columns, 2 ins. around and under all ordinary beams and girders, and 4 ins. on the sides of large, heavily loaded girders in mercantile or storage buildings.

These rules are intended to provide for buildings of any ordinary occupancy, including mercantile or manufacturing houses or buildings subject to conflagration exposures, and we believe such structures built in strict conformity with these specifications, though not fireproof to the last degree, will be found sufficiently fire-resistive to merit the term fireproof as generally used. This, however, is far from suggesting that concrete buildings as now being constructed are to be so regarded. The general practice at present, as already pointed out, involves too much carelessness in workmanship and too little insulation of steel work, defects which may not appear as vital under slight or moderate fire tests, but which in many cases would surely so appear, if the building were to be subjected to a long-continued hot fire, as from the burning of a stock of merchandise, or the severe attack of a conflagration.

HOLLOW CONCRETE BLOCKS.—The past year has witnessed a wide increase in the production of these blocks for various purposes, but no important changes in method of manufacture or use.

The formulation of a standard for the manufacture and erection of these blocks has had the careful attention of this Committee, but such action has thus far been deferred in the hope that field experience and laboratory tests would develop a general line of practice which might be found both safe and practical, and we still believe that before a final conclusion can be reached as to just what materials, what shapes and sizes and methods of manufacture produce the most fire-resistive blocks, it will be necessary to await further laboratory tests, particularly those under way at St. Louis. For the present we have to report that this year's investigations of the subject have tended to strongly confirm our previously expressed view that well-made blocks are suitable for small buildings, where no high temperatures or long-continued fires are to be expected, but that the hollow form in which they are made absolutely precludes their being classed as highly fire resistive, or suitable for fire walls, or for any buildings which may be subjected to severe fire.

The extensive series of tests under the auspices of the Government at the St. Louis laboratories and our Chicago laboratories jointly, are not completed, and we do not feel justified in making any extensive report on progress. However, we are at liberty to say that in the fire tests thus far made, as well as similar tests conducted for the City of Washington, D. C., practically all of the samples have been broken or cracked from unequal expansion of the various sides. The reason for such breaking is perfectly clear; concrete has almost exactly the same coefficient of expansion as steel, that is, it will expand at the rate of about .000006 of its length per degree of temperature, so that if one side of a hollow block be subjected to a severe fire long enough to heat it to several times the temperature of the other side (the connecting webs or sides being absolutely rigid and non-elastic) there must be a break between two sides. Of course, the thicker the wall or shell of a block is, the longer time will be required to heat it to the breaking point; hence, the thicker the shell, or, in other words, the nearer the block comes to being solid, the less likely it is to break under fire.

This objection, of breaking by unequal expansion, applies particularly to the simple, hollow, box-like block which is the one by far most commonly used at present, though it also doubtless applies in large measure to the so-called two-piece blocks, whether the inner and outer pieces be tied together by metal bonds or by irregular projecting wings of the block itself. In such cases the expansion of the inner side or wall would doubtless tend to break the bond between the two and seriously weaken the wall.

One of the most recent forms is a small solid block, the size and shape of an ordinary clay brick and to be used in the same way. From the standpoint of fire resistance the only objection to be offered against such blocks is that the cement, like that in any concrete, whether in block or monolithic form, will dehydrate in time on the application of high temperatures, and they are, therefore, less fireproof than good, well burned clay brick, though it would seem that for most ordinary small buildings such small blocks may be rated as equal to common brick for walls of the same thickness.

The larger solid blocks of so-called artificial stone made of finely ground stone and cement, which are used largely for decorative purposes, would doubtless compare favorably with natural stone, and as is the case with stone, any carved or uneven surfaces would doubtless suffer similarly from heat.

While we are not prepared to submit a detailed standard for the manufacture and use of hollow blocks, and even doubt the necessity for attempting to regulate very closely the manufacture of a type of building material which can only be recommended for low credit in fire resistance, the fact must be recognized that the material is being very extensively used and commercial necessity demands that it be given some definite grade as compared with other building materials. We, therefore, beg to state our opinion that a hollow concrete block wall is better than a frame wall for the simple reason that it is incombustible and will withstand moderate fires which would feed upon and destroy wood, but it is inferior to a brick wall on account of liability to breaking from unequal expansion, probability of continuous cracks through wall at imperfect mortar joints and especially on account of present tendency to poor workmanship in manufacture. The regulation of this personal element of workmanship can only come about in the course of years of experience and the recognition and control of it from our point of view will have to be left to the individual judgment of various authorities having local jurisdiction. In other respects, the highest fire resistance will be found in the block that has

1. The thickest shell, or being nearest solid (should never be less than 2 ins. thick).
2. That contains a good brand of Portland cement tested and found to conform to the standards of the American Society of Civil Engineers or similar specification.
3. That contains one part cement to not more than four parts sand or other aggregate.
4. Is made with the wettest mixture practicable.
5. Is most carefully cured or aged not less than thirty days before using, during which it is frequently moistened by water spray or steam.
6. Which provides solid blocks for the course on which joists or girders rest instead of allowing said timbers to rest on or hang to the inner side of a hollow shell which may break off.

SECTION 110 OF BUILDING CODE RECOMMENDED BY NATIONAL BOARD OF FIRE UNDERWRITERS. —REINFORCED CONCRETE-STEEL CONSTUCTED BUILDINGS.

The term "reinforced concrete" or "concrete-steel" in this Section shall be understood to mean an approved concrete mixture reinforced by steel of any shape, so combined that the steel will take up the tensional stresses and assist in the resistance to shear.

Reinforced concrete construction may be accepted for fireproof buildings, if designed as hereinafter prescribed; provided, that the aggregate for such concrete shall be hard-burned broken bricks, or terra cotta, clean furnace clinkers, entirely free of combustible matter, clean broken stone, or furnace slag, or clean gravel, together with clean siliceous sand, if sand is required to produce a close and dense mixture; and provided, further, that the minimum thickness of concrete surrounding and reinforcing members ¼-in. or less in diameter shall be 1 in., and for members heavier than ¼-in. the minimum thickness of protecting concrete shall be four diameters, taking that diameter, in the event of bars of other than circular cross-section, which lies in the direction in which the thickness of the concrete is measured; but no protecting concrete need be more than 4 ins. thick for bars of any size; and provided, further, that all columns and girders of reinforced concrete shall have at least 1 in. of material on all exposed surfaces over and above that required for structural purposes; and all beams and floor slabs shall have at least ¾-in. of such surplus material for fire-resisting purposes; but this shall not be construed as increasing the total thickness of protecting concrete as herein specified.

All the requirements herein specified for protection of steel and for fire-resisting purposes shall apply to reinforced concrete filling between rolled-steel beams, as well as to reinforced concrete beams and to entire structures in reinforced concrete. Any concrete structure or the floor filling in the same, reinforced or otherwise, which may be erected on a permanent centering of sheet metal, of metal lathing and curved bars or a metal centering of any other form, must be strong enough to carry its loads without assistance from the centering, unless the concrete is so applied as to protect the centering as herein specified for metal reinforcement.

Exposed metal centering or exposed metal of any kind will not be considered a factor in the strength of any part of any concrete structure, and a plaster finish applied over the metal shall not be deemed sufficient protection.

All concrete for reinforced concrete construction whenever used in such buildings must be mixed in a machine which mixes one complete batch at a time, and entirely discharges it before another is introduced. At least 25 complete revolutions must be made at such a rate as to turn the concrete over at least once in each revolution for each bath.

Before permission to erect any concrete-steel structure is issued, complete drawings and specifications shall be filed with the Commissioner of Buildings, showing all details of the construction, the size and position of all reinforcing rods, stirrups, etc., and giving the composition of the concrete.

The execution of work shall be performed by workmen under the direct supervision of a competent foreman or superintendent.

FORMS.—All forms and centering for concrete shall be built plumb and in a substantial manner with inside surfaces smooth and made tight so that no part of the concrete mixture shall leak out through joints, cracks or holes, and after completion shall be thoroughly cleaned out, removing shavings, chips, pieces of wood and other material, which should not be permitted in forms.

The reinforcing steel shall be accurately located in the forms and secured against displacement while the concrete is being placed and tamped.

Concrete shall be placed in forms as soon as practicable after mixing, and in all cases immediately after the addition of water.

Whenever fresh concrete joins concrete that is set, or partially set, the surface of the old concrete shall be roughened, cleaned and thoroughly slushed with a grout of neat cement and water.

Concrete shall not be installed in freezing weather; such weather shall be taken to mean a temperature of 32° F. or lower; concrete shall not be allowed to freeze after being put in place, and, if frozen, shall be removed.

The time at which forms and centering may safely be removed will vary from 24 hours to 60 days, depending upon temperature and other atmospheric conditions of the weather; the time for such removal to be determined by the Commissioner of Buildings.

PROPORTIONS.—The concrete shall be mixed in the proportions of one of cement, two of sand and four of other aggregates as before provided; or the proportions may be such that the resistance of the concrete to crushing shall not be less than 2,000 lbs. per sq. in. after hardening for 28 days, but for reinforced or plain concrete columns the mixture shall not be leaner than one part of cement, two of sand and five of the coarser aggregate in any case. The tests to determine this value must be made under the direction of the Commissioner of Buildings. The concrete used in concrete-steel construction must be what is usually known as a "wet" mixture.

Only high-grade Portland cements shall be permitted in reinforced concrete-steel constructed buildings. Such cements, when tested neat, shall, after one day in air, develop a tensile strength of at least 300 lbs. per sq. in.; and after one day in air and six days in water shall develop a tensile strength of at least 500 lbs. per sq. in.; and after one day in air and 27 days in water shall develop a tensile strength of at least 600 lbs. per sq. in. Other tests, as to fineness, constancy or volume, etc., made in accordance with the standard method prescribed by the American Society of Civil Engineers, may, from time to time, be prescribed by the Commissioner of Buildings.

The sand to be used must be clean, sharp grit sand, free from loam or dirt, and shall not be finer than the standard sample kept in the Department of Buildings.

The stone used in the concrete shall be a clean, broken stone, of a size that will pass through a ¾-in. ring, or good gravel may be used in the same proportion as broken stone, or broken hard bricks, or terra cotta, or furnace slag, or hard clean clinkers may be used.

Concrete-steel shall be designed in accordance with the following asumptions and requirements:

(1) The adhesion between the concrete and the steel is sufficient to make the two materials act together; the unit value of the adhesion is at least equal to the unit shearing strength of concrete.

(2) The design shall be based on the assumption of a load four times as great as the total working load (ordinary dead load plus ordinary live loads) producing a stress in the steel equal to the elastic limit, and a stress in the concrete equal to 2,000 lbs. per sq. in.

(3) The modulus of elasticity of concrete at 2,000 lbs. per sq. in. is equal to $\frac{1}{15}$ the modulus of elasticity of steel.

(4) The steel takes all the tensile stress.

(5) The stress-strain curve of concrete in compression, when the stress in the extreme fiber is 2,000 lbs. per sq. in. may be assumed:

(a) As a straight line.

(b) As a parabola with its axis vertical and its vertex on the neutral axis of the beam, girder or slab, or

(c) As an empirical curve with an area one-quarter greater than if it were a straight line, and with its center of gravity at the same height as that of the parabolic area assumed in (b).

(6) The assumption belonging to the common theory of flexure, where not modified by any of the foregoing, will apply.

(7) The steel shall meet the requirements of Section 21 of this code, which reads:

STEEL.—All structural steel shall have an ultimate tensile strength of from 54,000 to 64,000 lbs. per sq. in. Its elastic limit shall be not less than 32,000 lbs. per sq. in., and test specimens, ruptured in tension, must show a minimum elongation of not less than 20% in 8 ins. Rivet steel shall have an ultimate strength of from 50,000 to 58,000 lbs. per sq. in.

In the design of structures involving reinforced concrete girders and beams, as well as slabs, the girders and beams shall be treated as T-beams, with a portion of the slab acting as flange, in each case. The portion of the slab so acting shall be determined by assuming that in any horizontal-plane section of the flange, the stresses are distributed as the ordinates of a parabola, with its vertex in the stress-strain curve and with its axis in a longitudinal vertical plane through the center of the rib of the T.

The shearing strength of concrete, corresponding to a compressive strength of 2,000 lbs. per sq. in., shall be assumed at 200 lbs. per sq. in.

All reinforced concrete T-beams must be reinforced against the shearing stress along the plane of junction of the rib and the flange. Where reinforced concrete girders carry reinforced concrete beams, the portion of the floor slab acting as flange to the girder must be reinforced with bars near the top, at right angles to the

girder, to enable it to transmit local loads directly to the girder and not through the beams, thus avoiding an integration of compressive stresses, due to simultaneous action as floor-slab and girder flange.

Concrete in direct compression shall not be stressed, under the working load, more than 350 lbs. per sq. in. Reinforced compression members shall be designed on the assumption that this stress in the concrete will be simultaneous with one of 6,000 lbs. per sq. in. in the steel. Should the use of hooped concrete be proposed, the working stresses will be a subject of special consideration by the Commissioner of Buildings.

In the execution of work in the field, work must be so carried on that the ribs of all girders and beams shall be monolithic with the floor slab.

In all reinforced concrete structures, special care must be taken with the design of joints to provide against local stresses and secondary stresses due to the continuity of the structure.

In the determination of the bending moments due to the external forces, beams and girders shall be considered as simply supported at the ends, no allowance being made for continuous construction over supports. Floor plates, when constructed continuous and when provided with reinforcement at top of plate over the supports, may be treated as continuous beams, the bending moment for uniformly distributed loads being taken at not less than $\frac{WL}{10}$; the bending moment may be taken at $\frac{WL}{20}$ in the case of square floor plates which are reinforced in both directions and supported on all sides.

When the shearing stresses developed in any part of a reinforced concrete or concrete-steel constructed building exceed under the multiplied loads the shearing strength as fixed in this Section, a sufficient amount of steel shall be introduced in such a position that the deficiency in the resistance to shear is overcome.

When the safe limit of adhesion between the concrete and steel is exceeded, provision must be made for transmitting the strength of the steel to the concrete.

Concrete-steel may be used for columns in which the ratio of length to least side or diameter does not exceed twelve. The reinforcing rods must be tied together at intervals of not more than the least side or diameter of the column.

The contractor must be prepared to make load tests on any portion of a reinforced concrete or concrete-steel constructed building within a reasonable time after erection as often as may be required by the Commissioner of Buildings. The tests must show that the construction will sustain a load with a factor of safety for floors and structural members as required by Section 136 of this Code, which reads:

FACTORS OF SAFETY.—Where the unit stress for any material is not prescribed in this Code the relation of allowable unit stress to ultimate strength shall be:

As 1 to 4 for metals, subjected to tension or transverse stress;

As 1 to 6 for timber,

And as 1 to 10 for natural or artificial stones and brick or stone masonry.

But wherever working stresses are prescribed in this Code, varying the factors of safety herein above given, the said working stresses shall be used.

WHAT PERCENTAGE OF CLAY IS IT SAFE TO PERMIT IN SAND FOR CEMENT MORTAR?

Several articles have appeared in past volumes of Engineering News respecting the effect of clay and loam in sand on the strength of cement mortar.* The subject frequently comes up for discussion among engineers, and through the courtesy of Mr. E. S. Larned, of Boston, Mass., we are permitted to publish the following correspondence:

Mr. E. S. Larned, Boston, Mass.

Sir: There was one point brought up at our recent state convention which I confess rather scared me. If the conclusion be correct I am very glad to be forewarned. If, however, it was not justified, I want to be relieved from unnecessary apprehension.

It was with regard to foreign matter in sand. You know a number of tests have proven the greater strength of briquettes in the making of which different percentages of clay or loam were added to the sand. Page 46 Feb. "Concrete" again calls attention to the fact and conveys the impression that up to 12% of clay is beneficial rather than otherwise. I don't doubt it, so far as immediate tensile and compressive strength is concerned, but how about the life?

Iowa and Southern Minnesota are using rapidly increasing quantities of cement drain tile, most of them made from bank sand containing 1% to 6% of clay, some banks even 8% to 10%.

Mr. M. J. Reinhart, Assistant at Ames, Iowa, instanced a series of tests of cement briquettes with different percentages of foreign matter, made by him some years ago with the usual result of greater strength. The unbroken briquettes were, however, left in a shallow curing pan containing water for several months, with the result that total or partial disintegration resulted in proportion to the amount of foreign matter they contained.

What has been the general experience along this line? Not opinion but definite knowledge. What percentage of clay is it safe to have sand contain? Absolutely clean sand is seldom found. The cleaner, the better naturally, but ideal materials are seldom obtainable. To be explicit, are we justified in using a drainage concrete sand containing say not to exceed 5% of clay, when cleaner sand is not readily obtainable?

The fact of even greater percentages of clay in concrete that has stood for years with apparently increasing strength in footings, foundations and reservoirs, would seem to make some other cause responsible for the result cited, but I want to be sure.

L. L. Bingham,
Ex-President Iowa Association of Cement Users.
Estherville, Iowa, Feb. 26, 1907.

Sir: Your inquiry in regard to the effect of clay upon cement mortars and concrete has been duly received.

In considering the meaning of tests where clay has been added in different percentages to the sand, you must take into account both the character and size of the sand grains, the proportion used and the amount of water used, also the method of keeping the briquettes, either in air or water, between the time of making and the application of the test load.

While some experimenters have found that in certain sands they can use considerable additions of clay with good results, their determinations cannot be taken literally as applying to practical conditions.

It is a well known fact that clay, fine dead sand, even though siliceous, and other foreign materials, seriously retard the hardening of cement mortars and consequently would likewise effect concrete.

If the sand be perfectly dry, as in the case of laboratory tests, and the clay also dry and finely pulverized, you can see that a more intimate and even mixture can be obtained than in the case where the sand may be moist and the clay occurs in lumps. The results are also affected by the degree of mixing and manipulation, which in the laboratory is carried to a greater refinement than it ever reaches in practical operations.

If a moderately coarse sand be used, and the proportion of cement added is not quite sufficient to fill the voids in the sand, it is conceivable that a small addition of clay, sufficient in addition to the cement to completely fill the sand voids, would result in a denser mixture and consequently increase the compressive strength of the mortar. This result is contingent, however, upon the sand and clay being dry when first mixed, and the cement thoroughly and uniformly distributed through the fine aggregate.

Where clay is found in association with sand in a bank, it becomes a question of how the clay is contained, i. e., whether in the nature of silt uniformly distributed throughout the sand or in layers or strata of small or considerable depth. If it occurs in the latter form, it naturally follows that it will be in the form of lumps throughout the sand and ordinary mixing is not sufficient to break this up and distribute it uniformly throughout the sand voids, and in consequence, weak spots will be found in the mortar or concrete made from such materials.

If the sand grains and fine gravel be coated with clay, as is often the case, it will require a comparatively wet mixture and vigorous working to dissolve the clay sufficiently to enable the cement to bond with the sand and gravel surfaces, and even then results are more or less uncertain.

The presence of clay depends upon its physical condition, or its state of division, whether in such a condition that the individual atoms can mingle with the mechanical mixture as a filler, or whether it is in a colloidal or state of semi-solution (galatinous), such that it reacts on the total mixture, so as to prevent the bonding of the cement with the sand.

It may be difficult to anticipate this in actual practice without laboratory experiments to determine the physical condition of the clay. This may be done by alutriation and testing that portion of the clay which cannot be drawn down within a certain period of time by sedimentation, and which remains in suspense, thus indicating its colloidal state, which prevents the actual bonding of the cement with the aggregate, and, therefore, setting of the concrete.

I have in mind two instances of failure directly traceable to the condition last named, and upon washing the sand and gravel before use, good results followed.

For some time past engineers and concrete specialists have recognized the importance of analyzing and testing the sand before use, even though it appears upon ocular examination to be above suspicion. If you will do this, and test the sand as it occurs with cement, before use in any important work, you will avoid disappointment and oftentimes complete failure.

Clay in sand used for semi-dry concrete or cement sand blocks, or other cement products made of a semi-dry mixture, is more likely to give trouble and result in failure than where used in wet concrete mechanically mixed.

Inasmuch as your inquiry covers a most important feature in the use of cement, I am taking the liberty of forwarding, it together with my reply, to the Editor of Engineering News, New York City, requesting that he publish it in the correspondence columns and invite further discussion.

E. S. Larned, C. E.,
Chairman, Com. on Tests of Cement and Cement Products, National Association of Cement Users.
101 Milk St., Boston, March 2, 1907.

Mr. Larned also submitted copies of this correspondence to other cement experts and has forwarded us their replies, which we reprint as follows:

Sir: The statements contained in your letter to Mr. Bingham so fully agree with my ideas of the truth of the matter that I can add nothing thereto. Laboratory tests would, no doubt, show a favorable result for the use of clay, but in practice it is a very different matter, and I am in thorough accord with what you say in regard to it.

Very truly yours,
Clifford Richardson.
Long Island City, New York, April 25, 1907.

Sir: In practice I consider it unwise to exceed a low percentage of clay, or other similar fine material, because of the danger of its balling up and the possibility of its retarding the setting of the concrete. Furthermore, a sand containing a large percentage of clay is likely to be a fine sand throughout, and this in itself, without taking account of any possible action of the clayey matter, may reduce the strength of the mortar even as much as 50%.

A good, coarse sand with an admixture of clay will give totally different results from a fine sand having the same percentage of clay, the latter being far inferior.

All of this discussion emphasizes the necessity for tests of the sand, and these must be not merely void tests, but tests of setting, of density, and, if possible, of strength, in all the tests mixing the sand with the cement and water in the proportions and consistency in which they are used in practice.

Yours very truly,
Sanford E. Thompson.
Newton Highlands, Mass., May 16, 1907.

Sir: Replying to yours of the 24th inst. relative to clay in mortar, I would state that I agree with you in every essential particular.

The highest testing sand I ever examined contained over 20% clay and was used with entire success in heavy concrete mixed wet and by machine. In spite of its high tests, I should, however, consider this sand most dangerous for use in concrete blocks. Sand in concrete blocks should, I believe, be limited to not over 5% clay, and the less clay the better.

Another reason for keeping it low is that clay does not always mean real clay but the fine matter carried off by elutriation—which is often vegetable loam or other matter absolutely unfit for mortar and a very likely source of weakness. Laboratory strength tests are not fair criteria for this subject—unless on field made specimens.

Very truly yours,
W. Purves Taylor.
Philadelphia, Pa., April 26, 1907.

Sir: Your remarks are absolutely in accordance with our experience and we feel that there is little or nothing to be said as you have covered the matter very thoroughly. We may say, however, that we have made tests recently on two or three construction jobs where clay has been detrimental. We have found in every case, that if a fairly coarse sand carrying a considerable amount of clay be ignited so that this clay crumbles to a powder, there is little or no decrease in strength on account of its presence. If, however, this sand be mixed with cement in a moist condition and the clay is in nodules, as is usually the case, it is impossible to secure uniform mixing of the cement with this clay with the result that the clay particles are segregated throughout the mass of the concrete and a marked weakness is the result.

Yours very truly,
Sherman & Edwards.
Per H. L. Sherman.
12 Pearl St., Boston, Mass., May 21, 1907.

"LEAD WOOL" is a recently invented substitute for the time-honored method of running molten lead into the hub of a cast-iron pipe joint. The lead wool or finely shredded lead is put in place, strand after strand, on top of the oakum, and calked with an ordinary calking tool. This does away with the lead melting outfit, the clay rings, etc., and enables a tight joint to be made anywhere. It is particularly advantageous in wet trenches or for work in the rain or even under water where poured joints are difficult or impossible to make, and when attempted are often imperfect. A very important advantage is that the lead wool cannot run away and form an obstruction inside the pipe as sometimes happens with a joint made with molten lead. Such obstructions are only discovered when it is attempted to clean pipes with a scraper in the manner described in an article on another page of this issue.

It is claimed that the lead wool makes a joint as tight and durable as molten lead and that it has been used for some years in Germany. The Consolidated Gas Co., of New York, has recently ordered 100 tons of lead wool from the makers, the United Lead Co., 100 William St., New York City.

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New York City—or rather the Borough of Manhattan—is having a spasm of pavement investigation. Several associations interested in civic betterment have been showing up the office of the Borough President, which is responsible for pavement laying and maintenance. The showing up was so effectual that the Borough President trotted forth his Commissioner of Public Works and some other principal officials and promptly decapitated them as convenient scapegoats. It is interesting to note that the decapitated Commissioner, Mr. Dalton, was by his own statement a butcher before his appointment to office, and that the Borough President, instead of allowing Dalton to butcher the city streets, reserved for himself the chief responsibility of that operation. That the streets have been butchered all right, any one with half an eye can see for himself.

Seriously, whatever faults may have been due to official graft or to incompetency, the lack of proper organization, and particularly of a competent engineering staff in the Department, appears to have made certain that the taxpayers would pay dearly for poor pavements. It is bad enough for country towns and villages to put road repairs in charge of amateurs; but when it comes to putting such work, involving millions of dollars, into the hands of a butcher or a politician, or any one not a competent expert, the climax of absurdity is reached.

The Merchants' Association of New York very properly suggested the organization of an advisory board of engineers to cooperate with the new Commissioner of Public Works and the new Chief Engineer of the Bureau of Highways in preparing a plan for the reorganization of the administrative details of the Bureau of Highways.

The mistake was made, however, of proposing that this advisory board of engineers be selected by the civic associations of the city; a plan which the politicians accepted with alacrity. The City Club, however, refused to be drawn into the trap. Nothing would be easier, once this advisory board of engineers were appointed, than to shift to their shoulders the responsibility for final results. It is entirely clear that the work of street maintenance should be in the hands of engineers; but the selection of these engineers should be in the hands of the city officers whom the public will hold responsible for the final execution of the work in a right and an economical manner.

The Board of Public Service of the city of Cleveland is seriously proposing to dump the city's garbage into Lake Erie. As stated in a Cleveland newspaper last week:

President Sabin, of the Service Board, informed the Councilmen that the method now under consideration involves the collection of all garbage, and hauling it to Lower Town and uptown wharves. There it is to be dumped into scows, towed out into the lake, and dumped to the bottom.

Not only is the garbage to be thus disposed of, but dead horses, cats, dogs and chickens, as well. This can be done, of course, only with the permission of the federal authorities.

It is fortunate indeed that the Federal Government has the authority to prevent such criminal pollution of Lake Erie's water as Cleveland contemplates. If garbage could be "dumped to the bottom," there might be some defence; but an inconveniently large proportion of a city's wastes floats on the surface when discharged into water; and in a small body of water like Lake Erie would soon be carried to the shores, very likely to foul the water supply of some of the towns and cities along the Lake. There could hardly be a better illustration of the absolute necessity of Federal jurisdiction over all rivers and lakes wherever interstate interests are affected than this Cleveland proposition.

As our readers will recall, Cleveland has a municipal garbage reduction plant, which has been, we believe, well built and well managed; and its financial results were reviewed in our issue of May 2; yet the City Solicitor has been instructed to begin court proceedings to close the plant. The reason for this action is set forth in the following newspaper quotation:

Councilman Ernest Vick, whose constituents have lived in the ward in which the plant is located, raised such a complaint, however, that the City Solicitor was directed to begin the suit.

"I tell you the people in that end of the town can't stand the stench that comes from the plant," said Vick. "This council should protect the health of the people, and it is not protected, when such a foul institution is allowed to operate in the heart of the city."

It matters not what you do with garbage. You may treat it by burning or by reduction, and your disposal works themselves may be as free from smoke or dust or odor as a florist's establishment; yet the mere procession of refuse wagons from different parts of the city, going and coming to the disposal works, will affect the value of real estate in the vicinity and will cause all the residents and property-owners to rise up en masse and bring every sort of pressure to bear to cause the removal of the disposal works to some other locality.

It should be clearly understood, therefore, that the Cleveland situation is no condemnation of the disposal works themselves. Perhaps the Cleveland authorities can find some ward of the city where the disposal works will not be fought by the residents, or some adjacent municipality willing to harbor them; but if they succeed in finding a locality where the garbage disposal works will be welcome, it will be the first instance on record.

The latest scare dispatch from Panama reads as follows:

MAY NOT FILL THE CANAL.

Fear That Water Supply from the Chagres Will Be Insufficient.

PANAMA, May 30.—According to a report made by the minority of the Isthmian Canal Commission, it was estimated that the area of the canal and lake would not exceed 110 square miles.

It now appears from an excellent authority that that portion of the canal and lake surveyed up to date, which is less than half the ultimate total, exceeds 200 square miles, and fears are entertained regarding the sufficiency of the water supply. The Chagres River, it is argued, cannot supply water for this increased area.

Probably most of the readers will understand, what the newspaper reporter who sent the above dispatch evidently did not: hat the larger the area of Lake Gatun, the larger the amount of storage available for locking up the surplus flow of the Chagres and its tributaries for use in the dry season. As was stated in the report of Gen. Henry L. Abbot, the flow of the Chagres during nine months of the year is sufficient for all possible demands for operating the canal locks. During the other three months Lake Gatun itself will store the water needed to make up the deficiency in rainfall, and the larger its area, the less the variation in its level which will be necessary.

From authoritative sources we learn that the total area of Lake Gatun will be 225 square miles. This vast area will store so huge a quantity of water for the dry season that the criticisms of those who have prophesied a scarcity of water for lockage during that time will be permanently set at rest.

Those who sling mud at (not on) the Panama Canal work have declared that the present rate of monthly excavation from the Culebra cut is less after all than what the French accomplished in Culebra per month when their operations on the Isthmus were in full swing. It is true that the record of excavations which was bulletined with a flourish of trumpets to induce stock subscriptions from the prudent Frenchmen was for a considerable time in excess of a million yards per month; but only a small part of this excavation was done in the Culebra cut. De Lesseps and his associates sought to make the greatest show possible, and did the easiest digging first. The bulk of the excavation was that done by the big Slaven dredges in the swamps along the lower Chagres; and only about a fifth of the total monthly excavation was taken from the Culebra divide. To give actual figures by way of illustration: In May, 1886, the French dug 282,528 cu. yds. in the Culebra cut, most of it soft material. In April, 1907, the American forces took 879,527 yds. from Culebra, most of it material requiring blasting.

It has long been recognized that the economic location of steam railway lines is a matter requiring the best skill of the engineer; but the economic location of electric railways has yet to find proper appreciation. Because an electric car can run around a curve of 30 ft. radius or less and climb any grade up to 10 per cent., the promoters of electric railways have too frequently assumed that no particular skill or expense is needed in making the location. It is of course true that entirely different conditions control in economic electric railway location from those that govern in laying out steam roads. The cutting down of grades for example to increase train loads and reduce train mileage, so exceedingly important on steam roads of heavy freight traffic, is of trifling importance on electric railway lines, as at present operated.

One of the commonest faults of location in existing electric railways is the introduction of a sharp curve at the foot of a steep grade. Almost as frequently one may find a crossing with another railway line, steam or electric, at the foot of a grade, unprotected by derails or any safety-devices whatever. Accidents innumerable have been caused by both arrangements. Quite recently a bad derailment from one of these causes moved our British contemporary, "The Electrician," to remark:

It is with great regret that we have to record another serious tramway accident. . . It is of the usual kind—an overturned car on a sharp curve at the bottom of a hill. These accidents are considered by the public as *electric* tramway accidents, although usually the electrical working has no connection whatever with the accident.

The last sentence of the quotation is of course quite true except for the fact that the disregard of proper location principles is an exclusive characteristic of electric railway practice.

It may be claimed that in electric railway work there is often no choice whatever as to location, because franchise questions make only one route available to reach a given destination, and street widths limit the radius of curve which can be used. But while this is true for street railways, on electric railway lines through the country there is generally opportunity for the exercise of proper principles of location. Even in the case of lines laid on streets and roads, it is not uncommon to see needless errors of location. Thus, in one instance which we know of, in a double-track line with fairly heavy traffic on a wide street, the tracks run along the curbs for a considerable distance with the carriage-way between, but just at the foot of a steep hill, where the street deflects to one side, the tracks are drawn together and continue in the usual middle position. As

the carriage-ways thus must cross both tracks near the bottom of the hill just ahead of the bend in the street, conditions at this point are a clear source of danger to both vehicles and persons. In another instance, where an interurban trolley line, after running long in a valley bottom climbs the slope to the uplands, ample territory is available for a normal grade with easy curvature, yet the ascent is made by a grade close to the maximum, on a continuous sharp curve of about 120° central angle. This point is doubtless a troublesome and dangerous one even under ordinary slow and loosely-scheduled service; but equally important is the fact that it will always stand as a serious obstacle in the way of running fast and dense service over the line in question, unless indeed the risk of accident be disregarded altogether.

These are but mild examples of conditions which may be found wherever the trolley-car has penetrated. They are conditions caused almost wholly by the fact that the subject of location has not yet forced itself upon the attention of electric railway promoters. It has been put aside with the reflection that the construction of the line and operating the car service are the vital things, and that any kinks in the location are easily handled by the adaptable electric car and the watchful motorman. The time is fast nearing, however, when the matter will no longer be thus put aside, but will demand close study of principles and consistent application of these principles. The interurban line has already reached this stage, and there are now many high-speed interurban lines which are as excellent in their general location and its details as in their roadbed and track or in their motor and power-house equipment. In the future, we believe, no successful interurban line will be built without thorough attention to location.

A correspondent from Indiana sends us a postal card reading:

> We have the Solution for the "Bad Rail Problem." Our rail will be absolutely Non-Breakable.

This reminds us of Dr. Holmes' specification of the material used for part of the "One Hoss Shay":

> "Of the stoutest oak,
> That couldn't be split nor bent nor broke."

To satisfy curiosity we may state that our correspondent's "unbreakable" rail appears to be of the "continuous" type, a type on which hundreds of inventors have labored with little or no practical success.

CONCERNING BRIDGE STEEL AND SHIP STEEL.

The unification of specifications for shape and plate steel intended for different varieties of service is the objective point toward which have tended all efforts in developing structural steel specifications in recent years. Ever since we emerged from the period when steel and wrought-iron existed side by side, when steel of necessity was "high" and wrought-iron was "low," many men, both mill men and steel users, recognized that there was no advantage in having several grades of steel for practically identical service. It was a natural consequence that bridge and structural practice has approximated more and more to the use of but a single grade, the so-called "60,000 steel." Rivet steel, under present conditions, must still be specified under somewhat different requirements, and the same statement applies to boiler plate. The extraordinary degrees of deformation which these materials must endure in riveting and flanging respectively, and the temperature actions to which the metal of a boiler is subjected call for qualities which cannot yet be supplied in the structural grade of material. But it is not impossible that the continuing process of perfection of steel-making may result in overcoming even this difficulty and giving us steel which will unify the structural, boiler and rivet requirements at a price low enough to eliminate a separate structural grade from competition.

Future development of bridge-building practice has some bearing on this question, however. If it should come to pass, for example, that bridge and structural work generally should settle on the exclusive employment of sawing, planing and drilling in place of shearing and punching, and at the same time should virtually eliminate bending and offsetting so that every plate or member would go into the structure in its original straightness, undeformed, then we might find it very advantageous to adopt as standard material a steel of much greater hardness and strength than is now acceptable. Such a grade of steel could doubtless never be made suitable for boiler work, so that the boiler grade would be distinct from it. Moreover, the commercial needs for structural steel would probably create a demand for a tough and ductile, and therefore lower-strength, steel suitable for the simpler and more severe processes of fabrication. There would then be at least three grades of metal in place of the unified boiler and structural grade which we have suggested as an ideal. But be it noted, first, that any such condition in bridge practice is yet far in the future; second, that its advent will not be helped by the slow and gradual raising of strength limits, involving the coexistence of two specifications so close together that a single piece of metal may fall within the limits of both. The steel of high strength, high elastic limit, and [necessarily] high quality, will be produced, if at all, as a radical departure from existing steels, by a sudden jump in quality and price. On this view, therefore, the future interests of structural engineering are not furthered by the continued existence of two closely contiguous structural steel specifications.

There is no reason why the process of unification of structural steel should not be extended to all classes of use whose requirements are essentially the same as those of bridge work. Thus, ship steel is called upon to perform exactly the same service as that of steel in bridges or building frames. It should on every account be described and bought by the same specifications. Yet this evident principle does not seem to receive general recognition in practice. Two years ago a committee of the American Society for Testing Materials, in revising the society's earlier "Standard Specifications for Structural Steel for Bridges and Ships," which provided a single material for both uses, set up in its stead two separate specifications for steel for bridge work and ship construction. This was a distinct step backward. At the last annual meeting of the Society the subject of ship material again came up for consideration, in the shape of a discussion, which, however, was rather valueless and far from general.

There is a prospect that the subject will again be brought forward at the society's coming meeting. If this be the case, we trust that effective progress will be made toward eliminating the differences—many of them purely formal—between the bridge and ship steel specifications. Moreover, the specifications of steel for buildings should be included in this. There are now three separate structural steel specifications sanctioned by the American Society for Testing Materials, for steel for buildings, bridges and ships respectively. As to whether these bear a relation to any real differences in manipulation, service or stresses imposed in general practice, every engineer familiar with structural design may readily judge.

It is perfectly conceivable that some minor interests might be furthered by a very extensive differentiation of specifications for a material that serves substantially similar purposes. Thus, accidental conditions might lead to the formulation of separate specifications for steel used in steel freight cars, for steel used in city buildings, and steel used in mill-buildings; and it is not impossible [though we can hardly believe it] that the development of fixed standard practice in the corresponding fields of design would be furthered thereby. But the engineer can recognize no differences of service conditions to warrant such hair-splitting distinction of materials, even if these several specifications really secured different materials, which is uncertain, to say the least. If the bridge or the hopper-car subjects its material to greater intensity of impact and vibration, the engineer will take due account of the fact in his stresses, but he does not need a material of different properties. Otherwise why would he not build up his bridge of half a dozen different steels; one kind for the top chord, another for the floor-system, a third for the lower chord, a fourth for the tension diagonals, a fifth for lacing bars, and so on without end?

It is assuredly not the engineer who is helped by excessive multiplication of specifications. Certainly also it is not the manufacturer. The reason for the existence of many almost identical specifications side by side lies in no true need of the case, but in the fact that many minds have worked on their separate problems with no mutual understanding of any kind. The bridge steel specification evolves from the practice of bridge engineers, the ship steel specification from the ideas of shipbuilders and marine underwriters, and neither the bridge engineer nor the shipbuilder has discussed his problems with the other or realizes that both are in need of the very same steel. Now that we have, in the American Society for Testing Materials, a forum where these men come together, where the true uses of each material may find expression in specifications free from personal or accidental peculiarity, we should look for a wiping out of meaningless differences, and unification of requirements as far as practicable. We should expect, for example, to obtain a single specification for structural steel, whether the structure to which it is consigned be a ship, a building, a railway car, a bridge or a standpipe.

LETTERS TO THE EDITOR.

Values for Kutter Formula Coefficients.

Sir: In Engineering News of Feb. 28 appeared a letter from Mr. C. T. Mullings, asking for information regarding use of Kutter's formula in dimensioning tunnels and canals on the Truckee-Carson irrigation project.

I would say that the values of coefficient "n" adopted in the formula, 0.012 for lined tunnels and 0.015 for concrete-lined canals, are not considered too high in usual engineering practice in this country. The section obtained with the smooth concrete surface is such that the values correspond with those usually assigned for different materials by the authorities I have consulted. The use of the larger value, 0.015, for open channels is probably called for by reason of the fact that the bottom may often become temporarily roughened by loose material sliding down from above the walls, and because the lining might possibly be forced out or otherwise displaced so as to present uneven surfaces. The tunnel section should not become roughened from any cause.

The ratio of depth to bed width of the canals was certainly unusually great and quite out of the ordinary in American practice. The use of such a section did not influence the choice of the coefficient, as it is given due weight by the value of the hydraulic mean radius in the formula.

From the example quoted by Mr. Mullings, the practice in India seems to go the extreme of safety in providing sufficient carrying capacity.

Regarding actual tests of the discharge on the Truckee Canal, I do not think that the canal has been run full, as yet. It was planned to make very complete tests by measurements at different depths, and probably enough has already been determined to fix the values of "n" actually applicable. Information as to these can probably be obtained by addressing Mr. L. H. Taylor, Supervising Engineer, United States Reclamation Service, Hazen, Nev.

Very truly yours, W. P. Hardesty.

Portland, Ore., May 21, 1907.

[In connection with experimental determinations for the value of Kutter formula coefficients, a very interesting series of tests appear in this issue. Some of the canals tested would seem to bear a very close resemblance to the one noted in this letter.—Ed.]

Train Resistance Formulas.

Sir: In the editorial in your issue of May 16, on "The Economics of Railway Location: New Formulas for Railway Train Resistance," I note that you question the wisdom of using such low figures for train resistance as would be given by the formula quoted, especially "as a practical guide in railway location economics, or railway tonnage rating." I desire to call attention to a portion of my letter published with the report of the "Committee on Economics of Railway Location" in the same issue of the Engineering News, as follows:

> The tests show that no fixed rule can be deduced for train resistance that can be applied for all cases. Con-

ditions of track as to line and surface affect resistance quite materially. * * * Resistance per ton will vary widely with the loading of cars and condition of cars as to bearings, lubrication, etc. Therefore only general rules can be laid down and by experiment on each district these rules can be modified to suit conditions as they exist.

The resistances given by my formula are for fair weather conditions on well ballasted track, maintained in good line and surface, and do not take into consideration starting resistance or additional resistance due to journals being cool. For the average weight per car of train the figures are slightly in excess of the figures obtained by Mr. D. F. Crawford, of the Pennsylvania Lines, and by Mr. Max Wickhorst, of the C., B. & Q. Ry., who obtained practically the same results as Mr. Crawford. Both of these gentlemen have used the lesser figures in establishing tonnage rating, with good results. During the fiscal year ending June 30, 1905, an equated tonnage rating was used on about 80% of the main lines of the Union Pacific Ry., based practically on the resistances given by my formula. The results as compared with the figures of the previous year during which a flat rating was in effect, were an increase of 11% in the average weight of train behind locomotive, a decrease of 21% in the cost per ton-mile of train and engine expenses (including the wages of enginemen and trainmen), and a decrease in overtime. A large portion of this saving was due to the equated tonnage rating, which appealed to both the operating officials and the trainmen.

These low figures for resistance cannot obtain except where the appropriations for maintenance of both track and equipment are sufficient to keep them in first-class condition. Considering the results obtained, it certainly seems as though the low figures should be used in calculating the economy in maintaining first-class track and equipment.

I believe that more trouble has been caused by overestimating the power of locomotives at the various speeds than in underestimating the frictional resistance of trains. There are many variables that enter into the steam-producing power of a locomotive. The various proportioning of the parts affect the question, but the chief factor is the amount of fuel consumed and the quality of that fuel. Too many railways have adopted an arbitrary curve of mean effective pressure that has been obtained by some other road where conditions as to fuel have been first-class, with the result that engines have been overloaded and trouble followed. Many have assumed that the maximum grade of a district is always the controlling feature and have rated their engines for a speed of from seven to ten miles per hour on that grade. Frequently these grades have formed but a small portion of the entire district, and the loading has been such as to make it impossible for the engine to accelerate to and maintain the necessary speed required on the flatter grades in order to get over the district without overtime. Common sense must be used at all points in establishing a tonnage rating.

With reference to using these low resistance figures in railway location economics; an engineer should always be conservative in his estimates of comparative costs of operation between different lines. After having settled the question of the amount of traffic to be handled and the size of the locomotive to be used, the general practice has been to estimate the train miles per annum over the various lines and grades. The lower resistance formula gives the heavier train, consequently a less number of trains and train miles for the given traffic; and the estimated saving in operating expenses of one line over another would be the minimum saving that could be anticipated for the given traffic. In practice we are never able to have all of our trains go over the district with full tonnage, so it is proper to assume an average loading of somewhat less than full tonnage in estimating the train mileage. This amount would vary with the character of the adjacent country and the amount of the assumed traffic, as policy requires at times more trains than the actual traffic calls for.

Many roads are introducing velocity grades in connection with the work of grade reduction. Successful operation of such grades demands that conservatism be exercised in estimating the length of these grades. With the heavier train given by the use of the low resistance figures, and by the proper consideration of the power of the locomotive at the various speeds, little trouble can be anticipated in the use of velocity grades, particularly if calculated for a terminal velocity of about 10 miles per hour.

Because of the reasons stated, I believe it wise to adopt the lower resistance figures obtained by Messrs. Crawford and Wickhort, or by my formula, in estimating economy of first-class maintenance or the relative merits of different located lines and gradients, particularly as the conservative estimate places the engineer in a higher plane in the minds of the men who invest their money in the enterprise. We all admire an optimist, but we cannot afford to be too optimistic in this class of engineering work.

Yours very truly,

A. K. Shurtleff,
Asst. Engr., C., R. I. & P. Ry.

Chicago, May 25 1907.

A Rope-Drive Problem; Friction Uniform or Non-Uniform?

Sir: I offer the following solution of the rope-drive problem submitted by Mr. O. Grimm in your issue of April 4:

Since the angles of approach and departure are not given, let us assume the rope to run on and off horizontally. The tension is variable between 400 lbs. and 6,000 lbs. After reaching 6,000 lbs., due to friction between rope and drums, it remains constant.

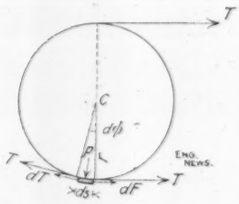

Fig. 1.

In Fig. 1 let ds be any element of arc and $d\phi$ the corresponding central angle. Let dF be the friction on the element ds due to radial pressure p (variable) and to f, the coefficient of friction. Let T be the initial tension, dT the increment due to friction on ds, and T' the final tension after passing over any arc ϕ. Let r be the radius of the circle. Summing moments about C and equating to zero gives $r\,(T + dF) - r\,(T + dT) = 0$, so that $dF = dT$. But $dF = f\,p\,ds$, $p = \frac{T}{r}$ and $ds = r\,d\phi$; therefore $f\,\frac{T}{r}\,r\,d\phi = dT$. Dividing both members by T we obtain $f\,d\phi = \frac{dT}{T}$, the differential equation between angle and tension.

Hence

$$f\int_0^{\phi} d\phi = \int_T^{T'} \frac{dT}{T}$$

Integrating between the given limits $f\phi = Log_e \frac{T'}{T}$.

Let $R = \frac{T'}{T}$ (the ratio of final to initial tension), then $R = e^{f\phi}$ With e (Naperian base) $= 2.71828$, $f = 0.2$, $\phi = \pi = 3.1416$, R (for half wind around drum) $= 1.9$ (approx.) from which the tension in the rope is found at the different points to be as shown in Fig. 2.

Consider now the whole body (Fig. 2) free, the rope being cut only outside the drums, at right and left. The sum of the negative (left) forces exceeds the sum of the positive (right) forces by 5,600 lbs. (34,162 − 28,562). A positive force (toward right) of 5,600 lbs. must be introduced to prevent motion. Three solutions:

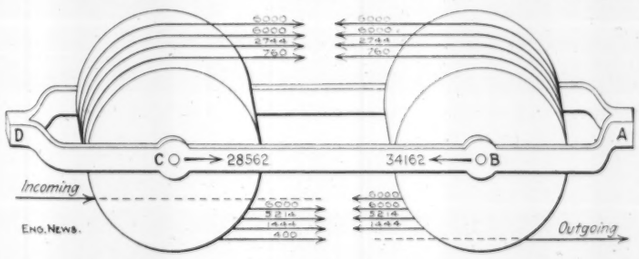

Fig. 2.

1. If a spring be attached at A and a positive force of 5,600 lbs. introduced, a tension of 5,600 lbs. will exist in the bar between A and B. At B a negative force of 34,162 lbs. is introduced, giving a resultant negative force of 28,562 lbs., which constitutes the thrust between B and C. Between C and D neither tension nor compression will exist.

2. If a spring be attached at D and a positive force of 5,600 lbs. be introduced, a compression of 5,600 lbs. will exist in the bar between D and C. At C a positive force of 28,562 lbs. is introduced, giving a resultant positive force of 34,162 lbs., which constitutes the thrust between C and B. Between B and A neither tension nor compression will exist.

3. If springs be introduced at both A and D each furnishing one-half the positive force required to hold the body in equilibrium, then between A and B a tension of 2,800 lbs. will exist. At B a negative force of 34,162 lbs. is introduced, giving a resultant negative force of 31,362 lbs., which constitutes the thrust between B and C. Between C and D a compression of 2,800 lbs. will exist.

The last result, 31,362 lbs., might reasonably be expected in practice where both bearings are firmly attached to rigid supports, each furnishing half the necessary resistance.

With the inclination of the rope given, the formula $R = e^{f\phi}$ would still enable us to obtain the tension, and the horizontal components of the forces in the incoming and outgoing ropes could then be considered.

S. E. Kelsey.
14th and Washington Sts., Kansas City, Mo., April, 1907.

Sir: I believe the following is a solution of the problem given by Mr. O. Grimm in your issue of April 4.

Mr. Grimm does not give the angle that the rope makes with the drum as it runs off, or on; I have assumed that it runs on at an angle of 45° with the horizontal and off the second drum at an angle of 60°. To calculate the coefficient of friction from the data we have:

$$\text{Com. log}\,\frac{T_1}{T_2} = 2.729\,un,$$

where u = coefficient of friction
and n = number of times rope is wrapped around drum $= 4^7/_{24}$ in this case.

$T_1 = 6,000$
$T_2 = 400$

From this equation we find $u = 0.1004$.

Applying this same equation making $u = 0.1004$ as found above we have the following tensions in the wire rope:

1.	400 lbs.	5.	1,144.8 lbs.	9.	4,043 lbs.
2.	444.4 lbs.	6.	1,579.6 lbs.	10.	5,542.3 lbs.
3.	600.2 lbs.	7.	2,151.3 lbs.	11.	5,997 lbs.
4.	835.1 lbs.	8.	2,949.2 lbs.		

The last figure should of course have come out 6,000 if our work had been absolutely correct, but this is near enough for engineering purposes. Now adding together all these tensions except the first and last, we have 19,298.9 lbs.

Yours truly,

R. E. Chandler.
Oklahoma Agricultural and Mechanical College, Stillwater, Okla., April 18, 1907.

Sir: In reply to Mr. Grimm's question concerning a rope drive, appearing in your issue of April 4, I would submit the following:

If the load t_n to be hauled is great enough in relation to the load t in the slack end to slip the rope, that is if the drum has to run a little bit faster than the rope, so that each rope takes only the amount of load that the friction is capable of sustaining, the coefficient of friction being assumed constant throughout, then the tensions in the various ropes can be computed as follows:

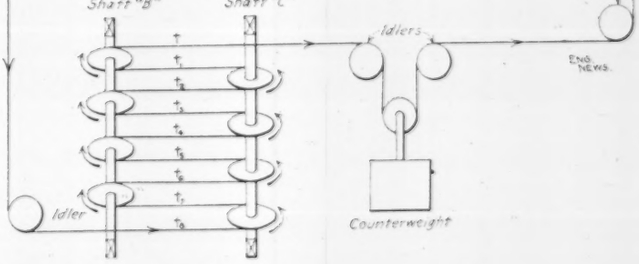

Fig. 3.

Let r = ratio of tensions in tight and loose ends for any one lap of rope.
R = ratio of tensions in tight and loose ends for total number of laps.
f = coefficient of friction.
ϕ = arc of contact for one lap in radians.
a = arc of contact for one lap in degrees $= \frac{360}{2\pi}\,\phi = 57.29578\,\phi$.
A = total arc of contact in degrees.
e = base of the Naperian logarithms = 2.7182818.

Then $r = e^{f\phi}$ .....(1)

or common log r = (log e) $f\phi$ = .4342945 $f\phi$

$= \frac{.4342945}{57.29578} f a = .00758\, f a$, or

common log $R = .00758\, f A$ .....(2)

Referring to the accompanying sketch (Fig. 3) the tensions in the ropes are as follows:

tension t = one-half the counterweight

" $t_1 = tr$

" $t_2 = t_1 r = tr^2$

" $t_3 = t_2 r = tr^3$ .....(3)

" $t_4 = t_3 r = tr^4$

etc.

or $t_n = tr^n$ .....(4)

where n = number of laps on driven drum and t_n = the tension in the last rope leaving from a number of laps equal to n.

From Eq. (4) we get $r = \sqrt[n]{\frac{t_n}{t}}$ .....(5)

The pull between the drums is $t_1 + t_2 + t_3 + t_4 + t_5 + t_6 + t_7 = tr + tr^2 + tr^3 + tr^4 + tr^5 + tr^6 + tr^7$

$= tr \frac{r^7 - 1}{r - 1}$, or in general $F = tr \frac{r^s - 1}{r - 1}$ .....(6)

where F = force between drums, between which there are S strands of rope.

For the example given $t = 400$ lbs., $t_n = 6{,}000$ lbs., $n = 8$ and $s = 7$; then under the conditions assumed above the value of r may be found by Eq. (5), thus,

$$r = \sqrt[8]{\frac{6000}{400}} = 1.4028$$

Inserting this value of r in Eq. (6) gives $F = 400 \times 1.4028 \times \frac{1.4028^7 - 1}{1.4028 - 1} = 13{,}502$ lbs., the required answer. The pull on shaft B will be $F + t = 13{,}502 + 400 = 13{,}902$ lbs. The pull on the shaft C will be $13{,}502 + 6{,}000 = 19{,}502$ lbs.

There are several practical considerations not taken into account in the above calculation, the principal ones being the stretch in the ropes and the varying value of the coefficient of friction under different conditions.

In designing a rope drive of this sort the number of laps and the amount of counterweight would be determined by the load it is required to haul and the lowest value of the coefficient of friction which would be when the rope was wet or greasy. According to the Trenton Iron Co.'s book on rope transmission, for a wet rope on an iron drum $f = .085$ and for a dry rope on an iron drum $f = .12$, while for a greasy rope on an iron drum $f = .07$. The designer would then calculate the amount of counterweight needed, using the lowest coefficient of friction and then to insure safety against slipping would probably increase the calculated value an arbitrary amount depending upon the personal judgment of the man. Now when the rope is dry and the surfaces gritty there would be a greater pull in the slack end than necessary, or viewed in a different light there are more laps of the rope than necessary, so that if other conditions are favorable, the first two or three half laps may transmit all the power, the tension in the remaining ropes being constant; we would then get the maximum pull exerted between the drums.

Another physical condition tending to cause the first few laps to transmit all the power is found in the stretch of the rope. The rope leading in onto the drum is under greater stress than the rope leaving the drum. There is therefore more rope coming onto the drum than going off of it. Since all the grooves are going at the same speed there must be some slipping of the rope on the drum which would be the greatest where the rope leaves the drum because at that point the drum is traveling faster than the rope.

The usual procedure with the problem as given would be as follows:

$t_n = 6{,}000$ lbs.; $f = .085$ for wet rope on an iron drum; $A = 180° \times 8 = 1{,}440°$.

From Eq. (2), log $R = .00758 \times .085 \times 1{,}440 = .92779$ or $R = 8.468$, then the tension in the rope running to the tension carriage $= t = \frac{t_n}{R} = \frac{6{,}000}{8.468} = 708.5$ lbs., or the counterweight should weigh $708.5 \times 2 = 1{,}417$ lbs., instead of 800 lbs., with the coefficient of friction as given by the Trenton Iron Co.'s book.

Now with the value of counterweight as calculated above and the coefficient of friction $f = .12$ for dry rope on an iron drum, the arc of contact necessary to haul the given load may be found by Eq. (2) as follows:

$\log R = .00758\, f A$ or $A = \frac{\log R}{.00758\, f} = \frac{.92779}{.00758 \times .12} = 1{,}020$

degrees, or the first six half laps under this condition could develop all the power. Let $t = 708.5$, $r = \sqrt[n]{\frac{R}{n}} = \sqrt[6]{\frac{8.468}{6}} = 1.4113$ and $S = 5$; from Eq. (6), $F = 708.5 \times 1.4113 \times \frac{1.4113^5 - 1}{1.4113 - 1} = 11{,}181$ lbs. due to the load in the ropes t_1, t_2, t_3, t_4 and t_5. The ropes t_6 and t_7 would both have the full loads of 6,000 lbs. and the force between the two drums is therefore $11{,}181 + 2 \times 6{,}000 = 23{,}181$ lbs.

Shaft B has also to sustain the pull in the rope t, and shaft C that in rope t_8. The load on shaft B is then $23{,}181 + 708.5 = 23{,}889.5$ lbs., and that on shaft C is $23{,}181 + 6{,}000 = 29{,}181$ lbs.

To get the actual amount of these loads carried by each bearing it would be necessary to know the pitch of the grooves in the drums and the position of the grooves relative to the bearings, also the location of gears, as the tooth loads on the gears affect the pressures on the bearings.

John S. Myers.

1925 Hunting Park Ave., Philadelphia, Pa., April 23, 1907.

Sir: I read with much interest in your issue of April 25, Mr. Hough's solution of the rope drive problem propounded by Mr. O. Grimm in your issue of April 4, and his demonstration is certainly unique and a very pretty one. The problem, however, could have been solved by the well-known formula for wrapping connectors:

$$T = S\, e^{f u \pi} \text{.....(1)}$$

in which

T = initial tension

S = tension in any other part

e = base of Naperian system of logarithms = 2.7182818

u = number of half laps on drums corresponding to S

and f = coefficient of friction.

From the above formula we get

$$T - S = S\,(e^{f u \pi} - 1) \text{.....(2)}$$

Applying this to Mr. Grimm's problem, and assuming

$$S = \text{final tension} = \frac{800}{2} = 400 \text{ lbs.}$$

$$T - S = 5600 = 400\,(e^{f u \pi} - 1)$$

from which we get

$$e^{f u \pi} = 15, \text{.....(3)}$$

Hence

$$\log e \times f u \pi = \log 15 = .4343\, f u \pi \text{.....(4)}$$

According to Mr. Hough's seal $u = 8 \frac{7}{12} = 8.5833$

and $u \pi = 8.5833 \times 3.1416 = 26.9653$

Substituting in Eq. (4) we get $11.711\, f = 1.7960013$, and $f = .10043$.

If the coefficient of friction should happen to be less than this, the rope, of course, would slip on the drums. Knowing the value of f, the value of S for any part of the rope may be determined from the formula by substituting the proper values of u, and the sums of the various tensions, less the contrary tensions of the initial and final parts as demonstrated by Mr. Hough, will be the pressure on the bearings.

This method of driving as applied to wire ropes was investigated by me in an article on "Endless Wire Rope Drives," published in the "Stevens Institute Indicator" of April, 1906. If Mr. Grimm is seeking to reduce the pressure on the bearings in his particular case, he will find some suggestions in this article that may be of service to him.

Yours very truly, Wm. Hewitt.

Trenton Iron Co., Trenton, N. J., April 30, 1907.

[The above letters represent two radically distinct views of the mechanics of a rope running over a driving sheave. The difference between the two merits separate statement. The one view is that the coefficient of friction is essentially uniform over the entire length of lap, as assumed in the letters of Prof. Chandler and Mr. Hewitt and also in the solution previously given by Mr. Hough. The other view is that the coefficient is not uniform; that over part of the total arc of contact it is constant and the maximum possible, in fact the coefficient of slipping; while over the remaining arc of contact the coefficient is zero, no friction whatever being developed, no driving action taking place, and the tension remaining constant over this arc. The second view is taken by Mr. Kelsey and Mr. Myers. It is also represented in a letter received from Mr. A. M. Crain, of Detroit, Mich., giving a solution of the problem.

The difficulty at the bottom of this difference of views may be set forth by beginning with the arguments advanced in favor of the second view.

Consider a single driving sheave, around which a rope makes a half turn, its tension being reduced from say 1,000 lbs. on the incoming side to 100 lbs. on the outgoing side. The incoming rope is stretched more than the outgoing rope; therefore a contraction of every element of rope takes place at some time during its passage around the sheave. In a given period of time, say 1 min., the revolution of the sheave winds in 100 ft. of high-tension rope, equivalent to say 99 ft. of free rope; during that same period the sheave pays out the same weight of rope (if all conditions of the case be permanent), or 99.1 ft. of low-tension rope. At the outgoing end the speed of the rope is, therefore, nearly 1% less than at the incoming end. Assuming that the incoming rope travels at the speed of the periphery of the sheave, the outgoing end is constantly slipping backward. This slipping develops a higher coefficient of friction than if no slipping took place. The slip, being due to the contraction caused by the decrease in tension, must of course distribute along the whole region of change in tension. Assuming it to begin at the outgoing end, it will extend back to the point where the corresponding coefficient of friction has developed the full change in tension required to pull the load on the rope. Thus a certain arc near the outgoing side will contain all the slip and all the driving adhesion; over the rest of the lap there will be no change in tension of the rope, and therefore no driving action.

The simplest counter-argument is that it is hard to conceive how the slippage can localize itself over a particular part of the total arc of contact, instead of distributing along the entire lap. It seems most reasonable to assume continuity of conditions over the whole lap of the rope, that is, uniformity as regards slippage and friction-coefficient from outgoing to incoming end. Slip occurring on one element of the circumference at once transfers the drop in rope-tension (which caused the slip) backward (in the direction of the high-tension end) to the next element, causing a slip there of somewhat smaller amount, and so on continuously along the entire lap. The driving friction thereby developed need not necessarily be the same as the full friction of slip, since the slippage takes place in successive amounts; its *average* amount at any element may therefore be much smaller, and indeed must be equal to the value computed from the total change in tension when distributed over the total arc of contact.

But the question really is not that of a single sheave, but the case of a multiple-lap continuous rope over two opposed sheaves. If for the sake of argument the assumption of localized slip be conceded as true for the single sheave, we can by no means conclude that it holds equally for the entire series of laps constituting the group. Rather, the theory of localized slip on an arc near the outgoing side should be applied to each semicircle of contact. There is no ground for assuming that conditions at one lap differ from those at another of the series. This argument gives results practically the same as those calculated from uniform coefficient.

Against this latter argument may be said: Since the outgoing rope has a smaller velocity than the incoming, we must assume either that the outgoing rope lags behind the velocity of the sheave surface, or that the incoming rope gains on the sheave surface. The latter assumption not being tenable, we must accept the former. But if the outgoing rope lags behind the sheave surface, it must be slipping backward, and therefore must be developing a friction in excess of that at the incoming end. This higher friction must exist over such a number of laps as necessary to produce the total change in tension from low-tension to high-tension side.

These opposing views are recommended to the reader's study. It appears that, in the case of the multiple-lap drive either view seems to show that the several lengths of rope between the drums have different velocities, the velocity decreasing as the outgoing side is approached. This would appear to involve bodily slipping of all laps except one. In this condition, it is reasonable to assume that the slip will distribute in such a way as to make the lost work of slippage a minimum. If the friction coefficient of the slippage is independent of the ratio of slip to travel, then the sheave having no slip would necessarily be the first sheave reached by the incoming rope. If the coefficient varies as the

ratio of slip to travel, then the minimum loss of work would occur when one of the intermediate sheaves has zero slip; the rope over the earlier sheaves would then slip forward, while the rope over the later sheaves would slip backward, the net driving effect being developed on these latter. In this case, of course, the tension in the early part of the multiple lap would exceed the incoming tension.

The entire matter does not seem to be touched in writings on the subject, though some suggestive facts are noted in a paper by Mr. Spencer Miller on "A Problem in Continuous Rope Driving," in Trans. Am. Soc. C. E., Vol 39 (1898), p. 165. Concerning the original query as to the pressure between the two drums of the rope-drive, it may be observed that the assumption of non-uniform coefficient of friction, the slip being localized on the last few laps, gives higher pressures, and is therefore on the safe side as concerns proportioning the machinery to resist these pressures.—Ed.]

[After the above was in type we received a further letter on the subject, containing a solution based on a third view of the frictional action between the rope and the sheave. The letter is reprinted below.—Ed.]

Sir: Mr. O. Grimm, of Chicago, submitted to your paper a rope-drive problem and Mr. A. C. Hough, of Homestead, Pa., sent you a pretended solution of it, printed in your issue of April 25, 1907. Mr. A. C. Hough inserted in the common formula for rope-drive the given tensions of hauling and tail rope to find a coefficient of friction which suited him for the calculation of the thrusts between the bearings. To this I would say that the coefficient of friction will never change its value to simplify a calculation and does not depend on the quotient of the tensions of said ropes.

To show the false conclusion of Mr. Hough I will, for example, assume that the tension in the hauling rope may be equal to that in the tail rope. If we adopt the method of Mr. Hough we would get a coefficient of friction $f = 0$, which of course never can be actually developed.

The editor of your paper cited that the assumption of a coefficient of friction must lead to a contradiction with the stated problem. Now I will show in this letter that this is not at all necessary. I use for my explanation as far as possible the same symbols as Mr. Hough.

To prevent slipping of a rope on a sheave there must be fulfilled the equations

$$Q \geq S_1$$

and

$$S_1 = \frac{P}{e^{f\phi}}$$

Or, in other words, S_1 is the tension produced in the tail rope by the tension P in the hauling rope.

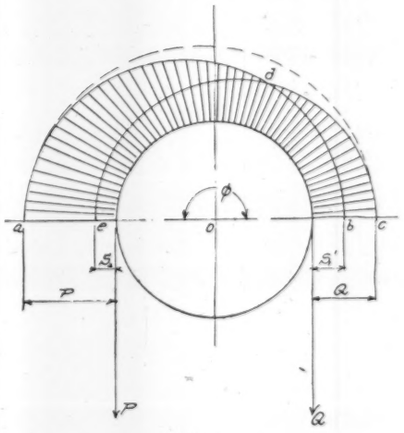

Fig. 4.

The curve $a\ d\ b$ in the sketch (Fig. 4) may indicate the tensions in the different places along the lap.

If we put a tension $Q > S_1$ in the tail rope and we apply the same principle as above we obtain

$$S_2 = \frac{Q}{e^{f\phi}}$$

S_2 is the tension produced by Q. Curve $c\ d\ c$ may represent this graphically.

We recognize that the tensions developed by Q and P are coming to an equilibrium in the point of intersection d. Therefore the tensions actually caused are shown by the lines between the circle and the combined curve $a\ d\ c$ and not, as Mr. Hough assumed, by a curve as indicated by the dotted line.

Applying the preceding to the problem as stated by Mr. Grimm we obtain:

$f = 0.13$ (Wire rope on cast iron).
Tensions produced by $S_{11} = 6{,}000$ lbs;
$S_{10} = 5{,}460$, $S_9 = 3{,}630$, $S_8 = 2{,}401$,
$S_7 = 1{,}600$, $S_6 = 1{,}061$, $S_5 = 750$,
$S_4 = 468$, $S_3 = 311$, $(S_2) = 230$,
Tensions produced by $S_1 = 400$ lbs;
$S_2 = 356$, $S_3 = 236$.

We see from these values that the tensions caused by S_{11} and S_1 are coming to an equilibrium at a point along the second lap, counted from the tail rope.

Under consideration of the angles between the ropes and center line of drums we find for the thrusts between the bearings 15,837 lbs. and 11,795 lbs.

I mention that I used a slide rule for figuring the tensions.

Very respectfully,
Chas. Kahlerth,

Cleveland, Ohio, May 27, 1907.

Notes and Queries.

Mr. John P. C. Cleck, of Philadelphia, informs us that the method of facilitating the driving of piles in dry ground by playing a hose stream on the ground around the pile (as described in our issue of May 23, by Prof. I. O. Baker) has long been used in Europe. It is also common, he states, to put a layer of clay puddle on the ground through which the piles are driven; and in Russia he has seen tar used to lubricate the pile and facilitate its descent.

R. C. G., Saginaw, Mich., writes:

Do you not think that wooden strips imbedded in the concrete, where a finished floor is called for, have a tendency to cause the finish to separate from the concrete and make it crack? I am using these strips in a hallway where they are putting in a cement base instead of a wooden one and, of course, the space between the two strips is to be carpeted and the base is exposed. The base is 15 ins. wide on the floor and is 6 ins. high on the wall. There is a ¾-in. top dressing of one part sand and one part cement and all around the strips the top coat has pulled away from the concrete and left a shell which sounds very hollow.

The strips are the regular shape used to put wood floor on, having beveled edges and being laid with the broad side down. I believe the difference in the two coefficients of expansion does not make this shape of strip a practical one on a finished floor. The concrete was put in very carefully, so it is not the poor concrete that causes the cracks.

From a sketch accompanying the above inquiry we judge the strips used have too much bevel. A very slight bevel is sufficient to hold a nailing strip firmly in the concrete. It is possible that the swelling of the wood strip may aid in cracking the finish coat away from the main body of the concrete; but the best way of avoiding trouble would seem to be to lay the finish coat before the body of the concrete beneath has set.

In our issue of April 18th, we published a short editorial note in which we stated that the earliest concrete arch bridge, either plain or reinforced, built in the United States was probably the Pennypack Creek Bridge over Pine Road in Philadelphia, which was built in 1893. Since the publication of this note we have received several letters submitting claims of other bridges to this honor. Three of these arches seem to be worthy of note and an explanation as to their absence in our account is proper.

The Cleftridge Bridge in Prospect Park, Brooklyn, was built in 1872 by John C. Goodridge out of what was then called beton-coignet blocks. These blocks were made of lime, cement, sand and broken stone, molded on the ground and set in place in the same manner as is customary in masonry arch bridges. The arch is a semi-circular span of 20 ft. While it is a concrete arch bridge, it is not in any way similar to the modern monolithic concrete arch.

The Golden Gate Bridge in San Francisco was built by Mr. Ernest L. Ransome in 1889. In several different published accounts it has been described as the first concrete arch bridge in this country. From information at our command, however, we have understood that this bridge is arched near the abutments on the under side, but the top is straight and the reinforcement is straight bars laid in one line along the bottom as a beam and not as an arch. As the distinction between a restrained beam and a flat arch is rather difficult to make, it would have been perhaps well to have made note of this bridge in our original article, but on account of the presence of but one line of reinforcement and the probability that the structure as a whole supports its load by beam action rather than arch action, it was thought best to omit it.

A third bridge, prior to the Pennypack arch, was built by Mr. James W. Pearl in 1892 at Pipestone Creek, Mich. This was of 30 ft. clear elliptical span and 6 ft. rise and was built of concrete, reinforced with No. 6 steel wire in both places. The bridge was removed the following year, not from any weakness, but on account of a suit at law over damages from obstruction of water power.

MODERN ABRASIVE MATERIALS AND THEIR USE IN SHOP PRACTICE.

By J. ROYDEN PEIRCE.*

KINDS OF ABRASIVES.

SANDSTONES.—The oldest types of abrasive wheels are those composed of sandstone. Though still used in a few limited classes of work, such as cutlery and tool finishing, etc., they are almost entirely superseded by the newer abrasives. Their superiority lies in their slow grinding and the consequent retention of the temper of high grade steels. Emery wheels will accomplish the same result if a proper selection is made, but considerations of cost, prejudice and ignorance maintain a demand for the primitive grinder.

EMERY.—Emery, or aluminum oxide with a mixture of iron oxide (generally about 40%), is by far the best abrasive known. It is a black, compact material, has the glassy luster peculiar to abrasive substances, and breaks with a conchoidal fracture.

CORUNDUM.—Corundum is a pure oxide of aluminum and is found in nature. It has generally a crystalline fracture. It is probably harder than alundum, though more brittle.

ALUNDUM (ARTIFICIAL CORUNDUM.)—This abrasive is a product of the electric furnace. It is a fused aluminum oxide with a purity of about 95%. Its fracture is conchoidal, though it seems to tend more toward a crystalline structure than emery.

ADAMITE (AUSTRIAN ARTIFICIAL EMERY).—This abrasive is also a product of the electric furnace. If color be an indication of purity, it is inferior to alundum, though it is claimed that the grains are tougher.

CARBORUNDUM.—The most remarkable artificial abrasive known is carborundum. It is a silicide of carbon, with a pure crystalline fracture of remarkable sharpness. When these new crystals break they invariably leave a new sharp edge.

BORIDE OF CARBON.—This is a "twin sister" of carborundum, and a substance which Moissan claims to be much harder. Unfortunately it is disintegrated by air, and its practical use is therefore impossible. Possibly future experimenters will overcome this disadvantage, but the high price of borax will prevent its competing with carborundum.

BORIDE OF SILICON.—This material is similar to boride of carbon and possesses the same properties.

TITANIUM CARBIDE.—Outside of aluminum oxides and carborundum this abrasive seems to be the only one which has any practical future before it. At a high heat, however, it unites with the nitrogen of the air and consequently cannot be used in kilns. In the non-vitrified bonds, however, and for certain grades of finishing and polishing cuts, it appears to have commercial possibilities. It is a bright, silvery material of no discernibly regular fracture.

The four elements, carbon, boron, silicon and titanium, have the quality of forming very hard compounds when fused in the electric furnace. Indeed, any two of them will form an abrasive. The author has tried many combinations of them, but none aside from carborundum (excepting titanium carbide) appears practical.

BONDS.

Bonds are rather a matter of chemistry than physics, but we cannot pass the subject without pointing out a few facts in relation to them. There are three properties which the manufacturer has to take into consideration—their hardness, toughness and elasticity.

The elastic bonds, such as rubber and shellac, allow a much greater latitude in the selection of grades and grits; that is to say, in the vitrified bonds one must be very careful not to get a wheel too hard or soft, or too coarse or fine, whereas in the elastic bonds it is not necessary to be so cautious.

PRELIMINARY CONSIDERATIONS.

Among the many recent developments in shop practice none is of more importance than the growing use of abrasive wheels. Though emery

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wheels have been known for many years, their use for accurate work and handling the harder varieties of steel is of recent origin. As yet, however, no attempt has been made to investigate scientifically the laws which govern their use; and although every maker gives in his "literature" tables of correct wheels for different purposes, he does not, as a rule, inform the purchaser that his rival's product is superior for some uses to his own.

It is commonly believed that the harder the abrasive the better adapted it is for hard materials, and that the coarser the grains of which it is composed the greater is its cutting effect. As a matter of fact the first assumption is true only within limitations, and these limitations are so many and important that the above rule is a very unsafe guide. For instance, carborundum, while very effective for cutting cast iron and brass, and particularly marble, does not show so great an efficiency when used for cutting steel. On the other hand emery, and corundum—natural and artificial—though inferior to carborundum in hardness often equal and in some cases surpass it in cutting effect on very hard materials. This paradoxical fact—well known to the trade—needs to be explained, and we shall attempt to do so in this article. The second assumption, that the coarser the grain the greater the cutting efficiency, is another fallacy; it is true only up to a certain degree of coarseness, different for each combination of abrasive and material, beyond which the efficiency again falls.

Below are a few illustrations based on current practice:

Abrasive.	Material.	Coarseness.
Carborundum	Glass	60 grit
Emery	Hard Steel	24 grit
Emery	Cast Iron	16 grit
Carborundum	Cast Iron	16 grit
Carborundum	Marble	4 grit

Here again we encounter a peculiarity which has been too little investigated.

Before going further we must call attention to the two different classes of work which abrasive wheels are required to perform; namely, finishing and cutting. In the former cases the wheel is called upon only to leave a satisfactory surface; its duty is light, its life long, and its structure and operation quite different from those required in the second case—the efficient removal of material. For the latter duty the wheel is coarser, is generally of softer bonding material, and often requires a different abrasive. These two requirements are entirely different and should not be confused. Laws or rules which answer for one are inapplicable to the other.

The following considerations apply almost entirely to the cutting efficiency of wheels, and where anything else is meant we shall specifically call attention to it.

Having given a few illustrations of the utter inadequacy of prevailing rules, either to account satisfactorily for abrasive phenomena or for use as shop guides, we shall look at the actual conditions which the abrasive particle encounters in its passage over the material which it is cutting and see if we cannot discover a satisfactory cause for the behavior of different combinations.

PRINCIPLES OF ABRASIVE WHEELS.

There is no reason to suppose that a microscopic particle of abrasive material acts in a manner different from that of an integral cutting tool; and in what follows it is proposed to analyze the action of abrasive wheels by assuming the cutting efficiency to be dependent upon the purely physical principles of a steel tool.

The amount of material removed by such a tool is dependent upon the depth of cut, the width of tool-face and the speed of passage of the tool over the work. That is to say, the efficiency of abrasive wheels, other things being equal, is proportional to

(1) Speed.

(2) Total face of cutting particles engaged.

(3) The penetration of particles in material.

(1) SPEED.—Claims have been made that an increase of speed above 5,000 ft. per min. produces no proportional increase of material removed. We can only partially agree with this, as there is no mathematical reason why such should be the case. There are, however, many limiting conditions, the most important being the strength of the bond and consequently of the wheel. In experimenting, it must also be borne in mind that in comparing different speeds the tangential pull must be the same; and also that, as the material is worn away faster at high speeds, there is probably a greater clogging of the abraded substance between the wheel and material. This either decreases the penetration and so detracts from the expected advantage of increased speed, or requires a greater pressure to keep the particles equally engaged. In either case the result is the same, the material removed not being directly proportional to the speed.

(2) There will probably be less doubt felt as to the truth of our second rule, that the efficiency is dependent upon the aggregate width of the cutting faces engaged. It is a matter of elementary knowledge that, other things being equal, the wider the face the more the wheel removes. There is no reason why this should not also be true of the minute particles themselves.

The cutting face of the wheel being made up of many particles, it is advantageous to have as large an aggregate of cutting edges in engagement as possible. Presuming their cut to be infinitesimal, a cutting edge in a straight line parallel to the axis of the wheel is ideal; but since this is not the case a serrated surface is preferable; in this way a larger surface is actually cutting. The greater ease of removing the abraded material by its retention in the pores of the particles must not be overlooked. From a reference to Fig. 1 the advantage of a serrated cutting edge is clearly seen. This is one of the superiorities of carborundum where its crystalline structure can be made available.

(3) We now come to the last and most intricate consideration, the penetration. The distance which a particle forces its way into the material is dependent upon the perpendicular pressure to which it is subject. This, while a simple condition in the case of one cutting edge in a straight line, becomes complicated when there are a large number of cutting particles, and when they are distributed upon the surface of a wheel.

In scientific order, the cutting surface should follow the penetration; since the edge engaged is jointly dependent upon the nature of the surface to be cut and the distance that it is forced into the material.

We may premise a common sense rule that there should be as much pressure as possible, limited by the strength of the wheel and the rapidity with which the particles dull.

EMERY VS. CARBORUNDUM. — Manufacturers make the bond which holds the abrasive particles together of a hardness which is just sufficient to allow them to be pulled off by the material when they are dull. This automatic sharpening is the most unique and probably the most important feature of abrasive wheels. Upon it depends the length of time that a wheel will continue efficient cutting. A wheel that is too soft, though a good cutter—owing to the continuous presence of fresh, sharp particles—is a wasteful instrument, since it soon wears away. On the other hand, a wheel that is too hard requires too frequent dressing because the dull particles remain in the sockets and the rate of cutting soon decreases.

In consequence of the necessity for allowing the dulled particles to be removed, the strength of the bonding material is limited; this in turn limits the strength of the wheel and the amount of pressure that can be applied. In practice, however, glazing limits the pressure long before the strength of the wheel does so.

Let us consider for a moment how minute a cut each particle makes. A 12-in. 16-mesh wheel with a 1-in. face, running at 2,000 r. p. m., removing 1 cu. in. of iron per minute (an extreme case) and having $\frac{12 \pi 16}{2} = 300$ particles around its circumference, gives every particle $\frac{1}{300} \times \frac{1}{2000} = \frac{1}{600000}$ cu. in. to remove each time it passes the iron bar. This, of course, is only strictly true of a straight line across the face of the wheel and parallel with the axis; but, presuming the actual cut of each particle to be five or ten times as great, it is still very minute. Suppose only one-fourth of each particle protrudes from the bonding material; that is, $\frac{1}{64}$-in.; and suppose also that the individual cut is $10 \times \frac{1}{600000}$ or $\frac{1}{60000}$ cu. in. It will be seen that only $\frac{1}{1000}$ of the protruding part is embedded in the material. We have given a limiting example as an illustration, for the pressure could not be greatly increased.

Referring to the diagram, Fig. 1, it will be seen that in the first case increasing or diminishing the depth of cut increases or diminishes the amount of material removed by the same amount. In the second case, however, we encounter a different condition. In extremely light or "skin" cuts, as they are known, the crystalline abrasive is not efficient, as only the points are engaged. Should the two diagrams be fair representations of the two surfaces (and although a microscopic examination shows a very promiscuous arrangement of particles, still their general surface is much like the diagram) given the same penetration from tip to bottom of the particle engaged, the dull abrasive will always lead in material removed.

It is, however, evident that more pressure will be required to force the dull than the crystalline abrasive into the work. On the other hand, a pressure on the tips of the crystals is apt to break them, especially in the case of carborundum which is more brittle. In a material which will not break the crystals, however, their sharp contours enable them to make something more than the microscopic cuts of their duller rivals. This explains the remarkable fact that though carborundum, the hardest abrasive known, while it shows marked superiority when used on cast iron and brass cannot show the same relation efficiency on hardened steel; whereas, in the case of more yielding substances like cast iron, brass, marble, and leather, the ease with which the crystals force their way into the work, and the great length of time they will last before breaking or dulling, put carborundum in the lead. That is to say, the efficiency of carborundum is mainly due to its penetration.

It is in extremely soft materials like marble that the great importance of the efficiency of penetration is seen at its best. Indeed, it is due to its quality of sharpness much more than to its hardness that it has captured the soft stone field by such large odds. As a corollary it follows from this that, where carborundum is substituted for emery or sand in cutting soft materials, less pressure should be exerted on the wheel.

COARSENESS.—Having considered the importance of the role which penetration plays in the efficiency of abrasive wheels, we are in a position to notice limitations of coarseness.

The coarser the wheel, the fewer cutting particles engaged; consequently, each particle must do more work. In the case of emery and corundum, the cuts of which are very light and which require great pressure to secure penetration, we are limited as to the pressure which we can apply, both by the strength of the wheel and by the rapidity of dulling. In carborundum we are limited by the brittleness of the crystals, since a hard material tends to break them. In both cases, therefore, there is a limit to the degrees of coarseness.

We have indicated a few of these in the table earlier in the article. These limits, though very definite things, are but little understood and still less appreciated; yet it is impossible to use abrasive wheels intelligently without taking them into consideration. Indeed, the fact that coarse carborundum (as coarse as 2 grit, that is, each grain ½ in. in its largest dimension) is a remarkably successful cutter in marble has only recently been discovered (although the substance itself has been known for ten years) illustrates how imperfectly the limiting properties of the size of grain have been investigated.

At this point it may be well to consider the probable possibilities of diamond wheels should diamonds ever be made commercially. It can be predicted with fair certainty that for finishing cuts, though the wheels will glaze very much

less, they will not leave a better surface nor remove the material with any greater rapidity than emery wheels. Indeed, it is a physical principle that a certain finish limits the size of the grain and therefore—the form of particle remaining the same—the amount of material removed. In very soft materials like marble, slate,

Fig. 1. Diagram Illustrating Ideal and Actual Cutting Face in Abrasive Wheel.

or limestone, carborundum has no cause to fear the introduction of the diamond, for its own great penetrative power will always keep it in the lead. In the substances of medium hardness, however, such as brass, cast iron, etc., the great wearing qualities of the diamond will make it unrivalled; and while in the harder materials, such as hardened and manganese steel, though it will not be more efficient for finishing cuts, for roughing out cuts it will immediately displace the aluminum oxides.

FORMS OF WHEELS.

The cutting efficiency of a disk is proportional to its area multiplied by the speed of a circle with a radius $\frac{2}{3}$ r. This form is not very much used, owing to the outer surface wearing away faster than the center and leaving it finally spinning about a small central area much like a top. A hollow ring, however, obviates this evil, and if it is broken by occasional openings to allow the abraded material to escape, it is excellent for certain classes of work.

As the cutting area is much greater than the shear cut of a wheel, the pressure per unit is much less; consequently the bond should be very soft. Furthermore, a dull abrasive should always be used, for since the pressure per square unit is light the penetration is still small and there must be as large a total of cutting faces as possible. For instance, in use for marble carborundum, which is unrivaled for shear cuts, does not give as good service in the form of disks or hollow rings as does emery. This again is an illustration of the important roles which penetration and cutting surface play, and emphasizes the fact that the form of the grain is of very much more importance than its hardness.

FINISHING CUTS.

ABRASIVES AND BONDS.—Carborundum can rarely be used for polishing. The sharp points of its crystals have a tendency to scratch which can only be overcome on materials that are extremely hard.

When selecting the abrasive it must be borne in mind that an elastic bond will allow a coarser grain to be used, as will a harder material. That is, if a shellac wheel is used instead of a vitrified wheel, and they are of the same grit, the finish of the shellac wheel will be smoother and, if the same wheel is used on cast iron and steel, it will leave a finer finish on the latter. Furthermore, if an emery wheel gives a desired finish, an alundum wheel to give the same finish must be a grade or two finer and a corundum wheel still more so.

While many wheels—possibly the majority—are selected as a compromise between finish and speed of removal of material, it must be understood that wheels which perform the two classes of work are generally quite different.

DEPTH OF CUT, ETC.—In designing abrasive machinery it is frequently necessary to know the pressure, etc., exerted upon the wheel or material when something more than skin cuts are taken. Below are given a few of the more important relations.

Fig. 2 shows the vertical and horizontal forces which the wheel exerts when the subtended angle and tangential force are given. It assumes that the abrasion is equal for equal sections of the arc. This is not strictly true, however, though for general purposes the formula is sufficiently accurate.

Fig. 3 illustrates the cutting efficiency of the wheel rim. The material is presented to the wheel in a direction along the X axis. It will be evident that at the top of the wheel there is much more abrading surface removing a given section of material than along the axis running through its center.

On a differential arc, $d\Theta$, the relation of cutting surface to material cut is represented by $\frac{d\Theta}{d\Theta \sin \Theta}$ or $\frac{1}{\sin \Theta}$. This is the cosecant. The x ordinates of the cosecant curve, therefore, show the efficiency of the rim at that point. The efficiencies of integral cuts are proportional to the average ordinates of their cosecant curves; or, what is easier to determine, to $\frac{\Theta}{\text{versin } \Theta}$. It will be seen how very efficient light cuts are in comparison with those which extend over a greater portion

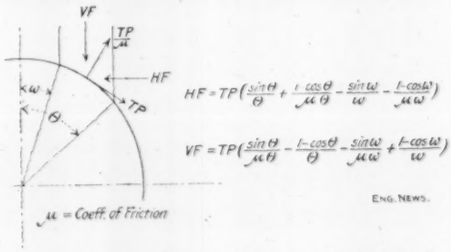

Fig. 2. Diagram Showing Values of Vertical and Horizontal Forces in Abrasive Wheels.

of the rim. This fact, well known in connection with wood saws, is equally important in the case of abrasive wheels.

Below is given a table showing the limiting sizes of various combinations, and also the increase of fineness required by the more crystalline abrasives to produce the same finish.

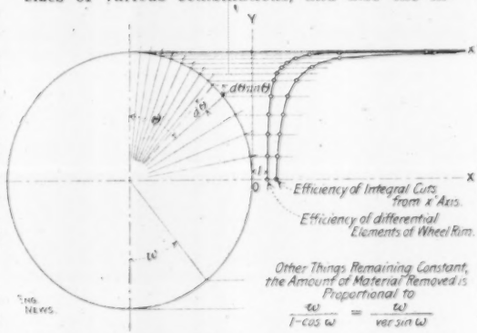
Y
X
x = r sin Θ
Efficiency of Integral Cuts from x Axis.
Efficiency of differential Elements of Wheel Rim.
Other Things Remaining Constant, the Amount of Material Removed is Proportional to
ω/(1−cos ω) = ω/(versin ω)
ENG. NEWS.

Fig. 3. Diagram of Efficiency of Rim in an Abrasive Wheel.

Class of Work.	Emery.	Alundum.	Corundum.	Carborundum.
Glass and Marble Polishing	150	200	240	.....
Fine Hardened Steel Work.....	40-80	46-100	50-120	60-150
Sharpening Milling Cutters....	40-50	46-50	46-60	50-80
General Machine Shop Use.....	20-24	20-30	20-36	24-40
Brass Castings...	16-20	20-30	24-36	30-40
Agricultural Implements	14-20	16-24	16-30	16-36
Rough Castings..	10-16	12-16	12-20	14-36
Marble	.....	.....	.....	2-4

BRICK ARCHES FOR LOCOMOTIVE FIREBOXES were discussed at the recent annual meeting of the International Railway Master Boilermakers' and the Master Steam Boilermakers' Association at Cleveland, O. A paper presented by Mr. G. W. Bennett (New York Central Ry.) gave some particulars of a test of an engine with a wide firebox to ascertain the efficiency of the brick arch and arch tubes. The evaporative power was increased about 15% by using the firebox arch, 10% of this being due to the arch and 5% to the arch tubes. Mr. T. Lewis (Lehigh Valley Ry.) considered the arch tubes unnecessary and the arch itself rarely of any use. Mr. J. German (Lake Shore & Michigan Southern Ry.) reported an average saving of 9% in fuel due to the use of brick arches, and presented the following statement of cost for two classes of engines; the cost of the hollow arch, however, does not include the material and labor for arch tubes:

Engines.	Class A		Class B	
Brick arch	Hollow	Standard	Hollow	Standard
Cost of material.....	$9.24	$4.92	$14.53	$8.18
Labor	.23	.10	.30	.18
Total	9.47	5.02	14.83	8.36
Extra for hollow..	4.45	...	5.47	...
Maintenance per 1,000 miles.....	4.52	3.01	4.52	3.01

SPRING MEETING OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS AT INDIANAPOLIS, IND.

Something over 300 persons, including members and guests, assembled at the spring meeting of the American Society of Mechanical Engineers, held at Indianapolis, Ind., May 28 to 31 inclusive. On Decoration Day this entire party attended the ceremonies of the unveiling of a bronze statue of Gen. Lawton at the Court House, and heard President Roosevelt deliver a strong speech on Gen. Lawton and the federal control of railways. This address in a way was the prime feature of the meeting; at any rate it was the best attended event, and added very largely to the interest of the meeting.

The event ranking next in point of attendance was a trolley excursion, via the Indianapolis & Northwestern Ry., to Purdue University, at Lafayette, Ind., about fifty miles north of Indianapolis, which occupied the entire last day of the meeting. Advantage was taken of this trip to further the business of the meeting, by holding the last of the professional sessions at Purdue.

The time of the meeting was distributed as follows: On the evening of Tuesday, May 28, an informal gathering in the parlors of the Claypool Hotel—where the Society made its headquarters—was addressed by Mayor Bookwalter in a welcoming speech, to which President Hutton made response for the Society. The first professional session was held on the next morning in the Palm Room of the Claypool. Wednesday afternoon was used for visits to manufacturing plants. Two parties were formed for this purpose, the one of which visited the Atlas Engine Works and the National Motor Vehicle Co., while the other visited the plants of Nordyke & Marmon and the Parry Manufacturing Co.

The second professional session was held on Wednesday evening, the third on Thursday morning, and the fourth and last at Purdue University on Friday morning.

The afternoon of Thursday, Memorial Day, was fully occupied by President Roosevelt's speech, and in the evening the Society's customary dress reception took place in the Assembly Room of the Claypool.

The trip to Purdue on Friday morning began at an early hour, the special cars leaving the Tractional Terminal at 8.10 a. m. The Terminal, by the way, is a noteworthy feature of Indianapolis: all the suburban and interurban lines radiating out from Indianapolis are brought together in a covered through or loop terminal, located only a stone's throw from the center of the city; the terminal was constructed by the street railway company, whose trackage rights in the city made it practically impossible for the outside lines to get in except over the company's tracks.

The trip to Lafayette was made without stop, and required little more than two hours; local Lafayette cars then took the party to the gate of Purdue University. In the absence of the president of the University, Prof. W. F. M. Goss welcomed the visitors in the University's new assembly hall. The professional session was then opened, occupying the rest of the morning. After a lunch served by the University, the party broke up into small groups which under the guidance of the professors went through the grounds and buildings. The return trip brought the Society back to Indianapolis shortly after 5 o'clock.

As the main business of the Society is transacted at its winter meeting, there was little to be done at Indianapolis. Announcement was made of the election of Andrew Carnegie as Honorary Member, and of the adoption of two amendments to the Constitution. A report of the committee charged with raising funds to pay the Society's share of the land on which the Engineering Societies Building stands was presented by Mr. F. J. Miller. It seems that the obligation is about $200,000, of which some $80,000 is covered by the net proceeds of the sale of the old property at 12 West 31st St., which brought $120,000. Of the remainder, $70,000 is covered by subscriptions, leaving $50,000 to be raised. Mr. Miller reported that the requests for subscriptions sent to the members

of the Society brought in only about 300 responses, 90% of the Society making neither positive or negative answer to the request. It is hoped, however, that continued work will bring better returns, and that the amount needed will be secured from the membership.

Professional Proceedings.

The adoption of a report on Standard Proportions for Machine Screws, progress in the evolution of a code for tests of refrigerating machines, and a symposium of papers on superheated steam, were the principal products of the meeting. Two committee reports and 19 papers made up the program. As only four sessions were available for handling this mass of material, the consideration of the individual subjects was more restricted than usual. There appeared also an increased tendency toward putting important comment or criticism in the form of written discussion, either before or after the meeting, as has long been the preferred method in the American Society of Civil Engineers.

The work of the professional sessions is very briefly summarized in the following:

FINAL REPORT OF THE MACHINE-SCREW COMMITTEE.

The several years' labors of the Committee on Standard Proportions for Machine Screws were brought to a close at the Indianapolis meeting by the presentation and acceptance of a final report. It required about four years to reach this point. Three earlier reports were submitted, but they were so strongly criticized that in each case the committee was continued with instructions to revise the report. In its final form the report meets the views of the manufacturers in the principal points concerned, and is thought to give a workable, practical standard. It covers machine screws of small sizes, denominated by gage numbers in place of diameter, and usually manufactured from stock of the size of the body by pressing the head and rolling the thread. The thread finally recommended is not exactly the Tyler thread originally recommended, i. e., a 60° thread with flats of ⅛ and 1/16 of the pitch respectively, but it has these widths of flat for limiting values. The sizes specified allow for a materially greater variation and clearance than provided in the first report. We will give in a later issue an abstract of the report, including the tables of sizes and limits.

Upon the presentation of the report, by Mr. H. K. Jones (New Britain, Conn.) of the committee, an extended written discussion by Mr. G. A. Gulowson (New York City) was presented; this made some radical criticisms of the report, suggested abandoning the numbered list and extending the U. S. Standard list, recommended a thread flatted ⅛ pitch at top and sharp at the bottom, and described a system of gages for controlling manufacture. The further discussion, however, was entirely favorable to the report. In particular, the representatives of manufacturers expressed their readiness to accept the standard as given in this report. The report was thereupon accepted by affirmative vote on a motion which also recommended that the report be referred to the manufacturers with the approbation of the Society.

REPORT ON TESTS OF REFRIGERATING MACHINES.

The work of the Committee on a Code of Rules for Conducting Tests of Refrigerating Machines is not yet completed, but a second preliminary report was presented by Prof. D. S. Jacobus (Hoboken, N. J.) as a basis for criticism and revision. The first report, fixing a standard tonnage basis for refrigeration (288,000 B. T. U. per ton), and standard conditions for determining commercial capacity, was accepted at the winter meeting of 1904. The present second report gives a tentative code for conducting tests of refrigerating machines, together with methods for obtaining the necessary measurements. It includes tables showing a standard form of stating the results of tests.

In discussion, Prof. R. L. Shipman (Ithaca, N. Y.) described at some length an arrangement for obtaining the weight of the condensation, which has been used with success at Cornell University, as superior to the method suggested by the Committee.

At the Chattanooga meeting of the Society a year ago, Prof. R. T. Stewart, of the Western University of Pennsylvania (Allegheny, Pa.) presented a report on a very extended investigation on the strength of lap-welded steel tubes subjected to external pressure. This work was subsequently supplemented by retests on some of the 10-in. tubes whose collapsing pressure had been measured; the tubes in question, embracing relatively few of the original series, had been distorted so little in their first failure that it was possible, after measuring their various diameters at the distorted section, to again test them, and thereby find their strength in the partly-flattened condition. In fact, the recoil of the test-apparatus used is so small that the second failure still did not completely flatten the tube, but permitted further retests. In one case 9 and in another case 11 retests could be made. Ten tubes were put through such retests. They were all of 10-in. nominal diameter, 20 ft. long. The results group in a very smooth curve, which shows that the collapsing pressure is a definite function of the degree of out-of-roundness, or the ratio of maximum to minimum external diameter, expressed by the formula

$$P_2 = 0.0926 \frac{P_1 - 47.55}{(M-0.874)^{1.25}} + 47.55$$

where P_1 = collapsing pressure of normally round tube,

P_2 = collapsing pressure of distorted tube; both in pounds per square inch,

and M = ratio of maximum to minimum outside diameter at place of greatest distortion.

The formula applies strictly to lap-welded Bessemer steel tubes for wall-thicknesses of 0.15 to 0.20 in., 20 ft. long between end connections. The practical range of applicability is doubtless much greater. An interesting fact shown by the plot of the results is that an out-of-roundness of 10% (i. e., $M = 1.10$), which is about five times that of a commercial 10-in. tube, causes a decrease in collapsing pressure of about one-third. It follows that ordinary safety factors are ample protection against a degree of out-of-roundness which would be easily seen on ordinary inspection.

Mr. A. F. Nagle (Buffalo, N. Y.), in a paper entitled "Balancing of Pumping Engines," recommended that the weight of plungers and reciprocating parts in vertical single-acting plunger pumping engines be proportioned to the mean suction and delivery pressures, in such a way as to equalize the work on the up and down strokes. The required weight per unit of plunger area is half the algebraic sum of intake and discharge pressures. The paper was discussed by Mr. I. H. Reynolds, Mr. E. H. Foster, Prof. D. S. Jacobus and Prof. W. T. Magruder.

Some figures on the fuel consumption of two rotary cement kilns, 7 ft. × 60 ft. and 8 ft. × 110 ft. respectively, were given by Mr. E. C. Soper (South Pittsburg, Tenn.) in a paper on "The Economy of the Long Kiln." These kilns were fired with natural gas, consumed respectively 12,750 cu. ft. and 20,000 cu. ft. per barrel, and produced 200 and 450 bbls. of cement in 24 hrs., the longer kiln having the greater output and being more economical. The corresponding stack temperatures were 1,300° and 450° F. respectively, indicating the source of the difference in heat consumption. The paper was discussed by Mr. B. E. Eldred (New York City), Mr. W. D. Ennis (Schenectady, N. Y.), Prof. R. C. Carpenter (Ithaca, N. Y.), Mr. E. A. W. Jefferies (Worcester, Mass.), and others. Mr. Eldred, separating the kiln operations into drying, calcining and clinkering, suggested that best economy might be obtainable by conducting the operations of calcining and clinkering in two separate kilns, run at different temperatures. The economy of calcining depends on employing a low-temperature flame, which is not ordinarily obtained with powdered-coal firing. The clinkering could be done in a regenerative gas-fired kiln, and the stack-gases in both processes could probably be brought down to 200°. Prof. Carpenter remarked that the results shown for the short kiln are very bad, and therefore the comparison invalid. The long kiln has been adopted to some extent in the Lehigh region, and has shown 10 to 12% increase of output and 10% decrease in coal consumption over the short kiln. The long kiln is clearly advantageous where wet raw materials are used, but the wet process is now very rare, and in particular the disadvantages of artificial moistening have made this variety of the wet process disappear rapidly. He himself designed a fairly successful wet plant only a few years ago, which uses 180 lbs. coal per barrel as against 150 lbs. for good dry practice.

An encyclopédic paper on "Ball-Bearings" was presented by Mr. Henry Hess (Philadelphia, Pa.). It comprised (1) a translation of the report of a very full study of ball-bearings made by Prof. R. Stribeck, of Berlin, (2) a condensation of this report, and (3) a discussion of proper methods of mounting and utilizing ball-bearings. The detailed nature of the paper precludes any abstract of it in this place, and we therefore refer to the advance sheets of the paper in Proceedings for June, 1907, or to its later final printing in the Society's Transactions. In discussion Mr. T. J. Fay (New York City) suggested that the materials used for balls and races are concerned in the success of ball-bearings. In some makes of bearings both the balls and the raceways are made of chrome-steel and other alloys. An ultimate strength of 230,000, an elastic limit of 220,000 lbs. per sq. in., an elongation of 12% in 2 ins. and "extension" [reduction of area?] of 48% are recommended as minimum requirements for ball-bearings; chrome-steel is probably the most suitable to meet these requirements.

"The Cost of Heating Storehouses," a paper by Mr. H. O. Lacount (Boston, Mass.), described observations made in a number of factory storehouses to determine the average winter temperatures, the variation of temperature, and the fuel cost for heating. The houses in question were heated mainly to prevent freezing of the automatic sprinklers, and the average inside temperature secured was only 41 to 49°. The heating cost per 1,000 cu. ft. per 24 hrs., in four different storehouses, varied from 0.24 ct. to 0.66 ct., averaging 0.39 ct. for all four. The author states that the cost of heating will generally be little greater than the cost of dry-pipe attachments to the sprinkler system. He also suggests that provision for filling the sprinkler system with strong calcium chloride solution is cheaper than either and gives a non-freezing wet-pipe system without the complication of a heating equipment. Such a solution can be made strong enough to be safe from freezing at 30° below zero, though ordinarily it is mixed in such strength as to freeze somewhat below 0° F. In discussing the paper, Prof. J. H. Kinealy (St. Louis, Mo.) pointed out that the author's figures for cost of heating demonstrate very clearly the accepted fact that steam heating is cheaper the lower the steam pressure. For three of the four cases given by the author the figures are:

House	1	2	3
Steam pressure, lbs. per sq. in.	1–2	12–15	60 & 10
Cost in cents per 1,000 cu. ft. per 24 hrs.	0.24	0.37	0.55

These figures give a larger-scale demonstration of this fact than was hitherto available.

Prof. S. A. Reeve (Worcester, Mass.) in a paper on "Analysis of Locomotive Tests," showed that the well-known locomotive tests conducted on the Pennsylvania R. R. testing stand at St. Louis, Mo., in 1904, exhibit a very large percentage of unaccounted-for heat, which percentage increases greatly with increasing load. This result is found by comparing the known heat supplied in the coal with the sum of the following: Combustion losses, heat absorbed in making steam, and heat lost up the stack, the latter quantity being calculated from smokebox gas analyses and allowance for cinders and sparks. Prof. William Kent (Syracuse, N. Y.) and Prof. W. F. M. Goss (Lafayette, Ind.) criticized this criticism, both attributing the discrepancy to losses in the stack gases. Prof. Kent stated that he never saw a boiler test using Western coal where the heat balance was able to account for the heat of the hydrogen and hydrocarbons;

these ingredients, while small in amount, account for a very large loss of the heat in the coal. Prof. Goss remarked that in the St. Louis tests the means provided for the measurements on which a full heat-balance study could be based were insufficient, and the records obtained from them were defective and therefore were not published. He stated that to his knowledge there are no analyses of smoke-box gases that are at all reliable, except perhaps some made at Purdue in the last year. The main difficulty lies in sampling.

Three other papers on railway matters were: "European Railway Motor Cars," an excellent descriptive summary by Mr. B. D. Gray (Providence, R. I.); "Superheated Steam on Locomotives in the United States and Canada," by Mr. H. H. Vaughan (Montreal, Can.); and "The Cole Locomotive Superheater," by Prof. W. F. M. Goss (Lafayette, Ind.). The latter reported some results of tests on the Purdue locomotive "Schenectady No. 3." As compared with results given by a similar locomotive without superheater, the superheated steam locomotive uses about 17% less steam [20 to 22 lbs. steam against 24 to 27 lbs. steam per I. HP.-hr.]. No coal results are given. Curves are given which show that the superheater in this engine has a "compounding" action, i. e., gives higher superheat with higher rate of evaporation. The paper was briefly discussed (in writing) by Mr. H. H. Vaughan and Mr. F. J. Cole (Schenectady, N. Y.).

The paper of Mr. Vaughan on locomotive superheater practice in America described the various types of superheater used on the Canadian Pacific Ry., which has over 300 engines equipped with superheaters, while only half a dozen engines on all other American railways combined have superheaters. The author then gives statements of comparative coal consumption of various types of locomotive, with and without superheater, in freight and passenger service and on different divisions of the C. P. Ry. Mr. Max Toltz (St. Paul, Minn.), in discussion, stated that the Great Northern Ry. and the Northern Pacific Ry. have superheater locomotives. The Great Northern has a Pacific type fast passenger engine and a Prairie type freight. The former shows 15 to 18% coal economy and 23 to 27% steam economy over locomotives without superheaters, and the freight engine shows a coal-economy of 12 to 15% and a steam-economy of 18%. These figures are for about 200° superheat, and are derived from daily service results handled with the endeavor to get the coal weights as accurately as possible. The higher superheats used in Europe (up to 300°) are probably responsible for the higher coal savings recorded there.

The paper of Mr. B. D. Gray on European Railway Motor Cars led to several interesting expressions of opinion concerning the value of the automobile car as developed for railway service. Mr. Harrington Emerson (Topeka, Kans.) argued that steam is the most suitable motive-power for railway service, and that regard to ease and cheapness of repairs makes it inadvisable to combine the locomotive and car in one structure. He would therefore use a compact locomotive of suitable design, hauling one or more trailers. The results with fuel oil in locomotive service make oil seem best fitted for such light work; a tank engine of the New York elevated railway type, fired with oil, should solve the problem for the present. Mr. Wm. Forsyth (Chicago, Ill.) seconded the view that a light locomotive with separate car would be most suitable. The trouble has been that usually a feeder line is equipped with an old worn-out locomotive, heavy, uneconomical, and entirely unsuited for the required work. While steam with coal firing seems best, yet the successful results obtained by McKeen on the Union Pacific Ry. with gasoline motor cars demand consideration. Generally similar views were expressed by Prof. W. F. M. Goss.

Aside from their railway connection, the three papers last mentioned pertain to one or the other of two subjects which were intended to be the chief feature of the professional work of the meeting: Superheated steam, and Automobile practice, the papers of Mr. Vaughan and Prof. Goss belonging to the former, while the paper of Mr. Gray may be considered as pertaining to automobile work. On this subject there were three other papers, namely, "Air Cooling of Automobile Engines," by Mr. John Wilkinson (Syracuse, N. Y.); "Materials for Automobiles," by Mr. Elwood Haynes (Kokomo, Ind.); and "Special Auto Steels," by Mr. T. J. Fay (New York, N. Y.). The last-named is too detailed to permit of abstract, but contains many facts and opinions concerning the characteristics and utility of various alloy steels for automobile work. The paper of Mr. Haynes is considerably briefer and general; we expect to give an abstract of it in a later issue. The paper of Mr. Wilkinson is in effect a statement of the factors involved in the utilization of air cooling for automobile engines. The favorable internal conditions are stated to be

> To present the minimum internal surface to the heat; to make this surface as smooth as possible; to carry off the hot exhaust gases at the bottom of the stroke before the main exhaust valve opens; to get rid of what is left with as little surface contact with the cylinder as possible; to reduce the friction of piston on the cylinder to a minimum; to keep all projections out of the cylinder; to make the compression just right to fit all other conditions.

The external conditions are: to provide efficient self-cooling surface on the cylinder, which involves mechanical difficulties not yet fully solved, or to proportion the blower and piping to deliver the proper quantity of cooling air to each cylinder. Good performance for air-cooled engines is quoted as follows: a four-cylinder motor 4 × 4 ins. with clearance 26% of the total volume gives 21 Brake HP. at 1,000 r. p. m. and 27 Brake HP. at 1,500 r. p. m., or 1 HP. for 7.4 cu. ins. piston displacement at 1,000 ft. per min. piston speed. It is expected soon to obtain 30 HP. at this same speed, or 1 HP. for 6.7 cu. ins. piston displacement. The author concludes that "the entrance of the air-cooled motor into even the high-powered field is only a question of time."

The discussion of these papers may be passed over, as it contained little of interest here.

Superheated Steam.

The subject of Superheated Steam was discussed in seven papers besides the two already mentioned dealing with locomotive superheaters.

The only theoretical or scientific paper among the seven was "The Specific Heat of Superheated Steam," by Mr. A. R. Dodge (Schenectady, N. Y.), which contains a summary of very extended experimentation done for the General Electric Co. The work was continued over five years, at great cost. Two general methods were used: water injection, and throttling, the latter giving the better results. The author concludes that at constant pressure the specific heat is constant for all temperatures, but that it varies with pressure according to the formula

$$c_p = 0.4754 + 0.00031\ p.$$

The paper was criticized rather severely. Prof. S. A. Reeve (Worcester, Mass.), Prof. R. C. Carpenter (Ithaca, N. Y.), Prof. F. C. Wagner (Terre Haute, Ind.), Prof. D. S. Jacobus (Hoboken, N. J.), and Prof. W. F. M. Goss (Lafayette, Ind.) spoke in discussion. The author's argument in support of the constancy of the specific heat with varying temperature was particularly attacked, and although the underlying experiments were characterized as the most stupendous attempt ever made to measure the specific heat of superheated steam, doubt was expressed as to the accuracy and thoroughness of the experiments.

One effect of the uncertainty as to the specific heat of superheated steam is that the efficiency of superheaters cannot be fixed. Mr. E. H. Foster stated that, with the lower values for the specific heat, as Dodge's, the efficiency of separate-fired superheaters would figure out as 60 to 65%, while with the higher values it would be up to 75%. This latter is considered improbable, although boiler efficiencies are often over 80%.

The results of another investigation of the specific heat of superheated steam, that of the German workers Knoblauch and Jakob, were used by Prof. A. M. Greene (Columbia University, New York City) to construct diagrams and tables of constant-pressure entropy curves for superheated steam, presented in a paper entitled "Entropy Lines of Superheated Steam." This paper of course was not well adapted for discussion.

A paper intermediate between the theoretical and the purely practical was presented by Mr. E. H. Foster (New York City), on "Flow of Superheated Steam through Pipes." Mr. Foster believes that

> a. The rate of heat transfer per degree difference in temperature per square foot of surface per hour increases with the steam velocity.
> b. This increase is more rapid in small than in large pipes.
> c. The percentage loss in heat decreases with the velocity, notwithstanding the rising rate of heat transfer.

The first of these assertions is not necessarily contrary to the principles of the conduction of heat. It refers to practical conditions, and testimony was offered by several in the discussion of the various papers on superheated steam, showing that when superheated steam flows in a pipe it is often, if not always, surrounded by a sheet of water on the inner surface of the pipe. This water, being probably at a lower temperature than the steam, may act as heat insulation, in proportion to its thickness, and if a higher velocity of steam means a less thickness of water film, the loss of heat through the pipe would be increased with higher velocity. However, the difficulties in measuring correctly the temperature of superheated steam in a pipe, which were referred to by several speakers, probably affect all such measurements of heat loss as those on which Mr. Foster's conclusions are based. Prof. D. S. Jacobus in fact expressed the belief that accurate experiments would probably show the loss in saturated and superheated lines to be the same per degree temperature difference.

Mr. Foster's paper recommends proportioning pipes, to carry superheated steam, for a velocity of 6,000 to 8,000 ft. per min. when 100 to 200° F. superheat is used. The author explained this to refer to flow at normal load, under such conditions that the overload velocity would be about 9,000 ft. per min. In turbine work, where the overload might be 100%, a lesser normal velocity, say 4,500 ft., would be proper. This figure agreed with that given by Mr. A. H. Kruesi (Schenectady, N. Y.) as the practice of the General Electric Co. in Curtis turbine installations; Mr. Kruesi, however, made the reservation that the size of the engine would affect the matter to some extent.

Some direct and healthy criticism of present practice in constructing superheaters was advanced by Mr. R. P. Bolton (New York City) in a paper entitled "Superheat and Furnace Relations." The author argued that close temperature control is almost necessary with superheat, and that existing designs are not at all adapted to secure stable temperature. Aside from this, it is not to be expected that a good superheater can be obtained by merely placing a superheater coil in any part of a boiler setting where there happens to be space for it in the maker's standard design of boiler, and connecting the steam supply to it by "strange and undesirable pipe connections." Support was given to this argument by Mr. A. H. Kruesi, who reported the variations of steam temperature in a plant of 8 360-HP. boilers. These were fitted with superheater coils, to give 125° superheat under normal load, which requirement they fulfilled. Temperatures taken at the steam outlets during 24 hrs. showed the superheat in one boiler to vary from 106° to 170°, in another from 57° to 138°, etc. These variations are so large as to necessarily mean trouble. More thorough design of superheaters should avoid such conditions.

Mr. S. L. Kneass (Philadelphia, Pa.) in a paper on "The Use of Superheated Steam in Injectors" showed that it is desirable to run injectors with saturated steam. The inflowing water must condense the steam, and to do this must absorb more heat from superheated than from saturated steam. Both the temperature range and the capacity of an injector will be reduced with superheated steam.

> The practical effect of superheated steam on the action of an injector is to reduce the maximum capacity, increase the minimum capacity, and to lower the limiting temperature of the water supply with which the injector can operate. Further, with high pressure and superheat an inefficiently designed instrument is inoperative. It is therefore advantageous and usually practicable to have a special pipe to supply the injector with saturated steam.

Mr. Geo. H. Barrus (Boston, Mass.) reported "Experiences with Superheated Steam," a paper giving figures from nine plants of superheaters or engines using superheated steam. One particular observation, noted in a plant using steam at 149 lbs. pressure with 337° F. superheat, a total temperature of 697° F., was that the packing and gaskets of pipe flanges and valves were burned out, and Van Stone pipe-joints with corrugated copper gaskets were set leaking. Running at 550° F. previously, the plant had given no trouble and there was no leakage at any point.

The question of fittings and pipe-line construction for superheated steam was separately considered in a paper by Mr. M. W. Kellogg (New York City), on "Materials for the Control of Superheated Steam." Some matters brought out in this paper are: the construction of welded or turned-over (Van Stone) joints for steel pipe, it being generally found that screwed joints are not satisfactory for superheated steam; the advantage of welding up wrought steel piping in such a way as to eliminate cast fittings; the necessity of thorough workmanship in valves, in which case a wedge valve is satisfactory; the desirability of using cast steel in place of cast iron and bronze, eliminating these two metals entirely because of their weakness at high temperatures; the frequent failure of corrugated copper gaskets in superheated steam lines; the need of having specially trained erectors for putting up superheated steam piping.

In some of these points the discussion brought dissent from the author's views. There was general agreement that corrugated copper gaskets fail mysteriously and frequently under superheated steam. Substitutes for packing joints are corrugated soft steel gaskets, thin flat rings of soft steel, round-wire copper gaskets, etc. Attention was called to the fact that, since the action of a gasket depends on its being pressed into tight contact with the joint face, the gasket is ineffective if it is too wide.

Cast iron for fittings found a defender in Mr. E. H. Foster, who stated that superheaters of this metal have been in use for many years, at temperatures up to 1,000° F., without failure or great deterioration, and that cast-iron valves have been used quite largely with superheated steam. Cast steel is, of course, excellent if well made so that it is not porous. Bronze also has been found satisfactory, and works well in gaskets. Corrugated copper gaskets have given trouble on saturated as well as superheated steam lines. While they have been used in a number of instances without trouble, Mr. Foster has not found them generally satisfactory. He differed with the author as to considering superheated steam work radically different from saturated steam work, and believes rather that the distinction should be between moderate and high superheat. The pipe-line generally gives no trouble up to 500° temperature, but beyond this gives a great deal of trouble. However, sometimes a pipe-line that leaks with saturated steam gets tight with superheated steam, and later, with saturated steam, leaks again.

Mr. A. H. Kruesi reported on cast-iron less favorably. In one plant using 125° superheat tons of cast-iron fittings were scrapped inside of a year. This was not due to expansion troubles, as similar bad results had been found with many pipe-lines, both fixed and free. In fact, he believes even for saturated steam cast steel alone is suitable. He strongly endorsed the views expressed about corrugated copper gaskets; they deteriorate in an unexplained way, and get quite dead at high temperature. Moreover, they give opportunity for pulling up the joint bolts unequally, which is sure to give rise to trouble. He disagreed with the author in the matter of valves, believing that no gate-valves should be used, as reliance for tight closure must always be placed on globe-valves; generally these can be used as angle valves, with little more friction than a plain elbow.

Mr. Max Toltz reported that cast and malleable iron superheaters gave no trouble and that male and female joints with a copper gasket consisting of round copper wire proved successful, getting tighter with age. He endorsed the preference of globe-valves to gate-valves.

Speaking on the general question of superheaters and their performance, Mr. J. R. Brown (Mansfield, O.) gave two formulas used in designing a standard line of combined superheaters. If T is the temperature of the gases, S the degrees of superheat, then

$$\frac{1}{(T-378)^{0.16}} = 0.172\ S + 0.294$$

and the superheater surface required, in square feet per boiler horsepower (30 lbs. steam per hr.) is

$$X = \frac{10\ S}{2\ (T-378) - S}$$

which involves the transmission of 3 B. T. U. per hr. per sq. ft. per degree temperature difference. He also held that the combined or boiler-setting type is the standard type of superheater, as it requires no additional space, and reduces the plant capacity less when one unit is out of commission. When the gases are not hotter than 1,000°F., the superheater coils need not be flooded for starting up.

Mr. Max Toltz (St. Paul, Minn.) gave 2.5 to 3.6 B. T. U. per sq. ft. per hour per degree temperature difference as the usual rate of heat transmission in superheaters, but stated that some superheaters have shown as much as 11 B. T. U.; higher heat-transmission figures than are customary should be striven for in superheater work. Concerning the question of combined vs. separate-fired superheater, he gave several sets of figures of steam and coal saving with combined and separate superheaters, over saturated steam. In all cases the coal-saving of the separate superheater was much less than that of the combined, and often was negative, i. e., saturated steam was cheaper in coal. For example, a 250-HP. compound engine with 202° superheat showed 20% steam saving over saturated steam; the coal saving was 14% with the combined superheater, but only 4½% with the separate superheater. In another case, with 144° superheat, the steam saving was 7%, the coal saving 3% and — 8% for the two types of superheater, respectively.

Mr. A. H. Kruesi quoted as a general figure of steam saving, 1% per 12° superheat, varying however with the superheat so that 10 to 14% steam saving was generally obtained. High superheat is not desirable. The coal economy is generally slight. His own results agree with the experiences given in Mr. Barrus' paper, that the coal results are generally about equal for saturated and superheated steam. His preference in steam turbine work is to use no superheat for units up to 1,000 KW., and use a maximum boiler superheat of 125°F. with the largest units, 5,000 KW. and up. Operating engineers generally object to superheated steam, because of maintenance troubles.

Mr. Foster and Mr. Toltz, on the other hand, asserted that while these views might be correct for turbine work, they do not apply to engine plants. In these latter the small plants show decided economy with superheated steam. Many instances can be cited of definite savings in engine plants of 100 to 200 HP. with superheated steam. In fact, the proportionate saving is greater in small than in large plants. But engines, and turbines also, must be properly designed to suit superheated steam.

One result of the discussion of superheated steam was a motion, initiated by Mr. M. Toltz, for the appointment of a committee to report on the flow of superheated steam in pipes. This motion carried, with the amendment that the question of the advisability of appointing such a committee be referred to the council.

ABT RACK LOCOMOTIVES, built by A. Borsig, of Berlin, are to be used to operate the summit section of the Trans-Andine Ry., between Argentine and Chili, now nearing completion. The rack-rail division is some 65 miles in length and the portions of the division where racks are not laid have maximum grades of 2½%. The rack rail used is of the three-bar Abt type, and not the solid rail used on the Jungfrau Ry. The locomotive weighs 56 gross tons in working order and runs on a meter gage track.

THE EFFECT OF CHANGES IN CANAL CROSS SECTIONS UPON THE RATE OF FLOW.

By F. W. HANNA.*

In the construction of a canal it is usually necessary to provide for carrying its waters through culverts, flumes, siphons and other important changes of cross section of waterway; and in order to compute properly its capacity, some estimate of the effects of such changes on the flow must be made. Works on hydraulics discuss in detail the subject of loss of head due to contraction and expansion of cross section for the flow of water in pipes, but little definite information is contained in them on this subject for flow in canals. It is the object of this paper to indicate briefly methods of determining mathematically the loss of head in canal flow due to contractions and expansions of cross section of waterway, either modified or unmodified with a reducing section. For this purpose let the following symbols have the significance below assigned them.

b = Proportion of wetted perimeter on which contraction or expansion is suppressed.
c = Kutter's coefficient.
a = Water depth in feet in reducing section.
g = Gravity.
h_c = Loss of head in feet due to contraction of canal cross section.
h_e = Loss of head in feet due to expansion of canal cross section.
h_f = Friction head in feet in reducing section.
L = Distance in feet of any cross section of reducing section from its upper end.
h_v = Difference in feet between velocity heads above and below change of cross section.
$H = h_v + h_f$.
m = Weir and orifice coefficient of contraction.
q = Canal capacity in second-feet.
r = Hydraulic radius in feet of cross section of reducing section at distance L from its upper end.
v = Mean velocity in feet per second in reducing section at distance L from its upper end.
v_1 = Mean velocity of canal in feet per second above change of cross section.
v_2 = Mean velocity of canal in feet per second below change of cross section.
w = Canal bottom width in feet above change of cross section.
ϕ = One-half of angle between converging sides of base of reducing section.
Θ = Angle of side slopes in reducing section.

The change of a canal cross section to a smaller one is usually accompanied with a reducing section making a gradual change between the representative cross sections. This reducing section consists of wings or channel side walls of various forms making definite angles with the axis of the canal. As a result of this arrangement there is an increase of velocity head and a loss of head due to partial contraction and to friction as the water passes through the reducing section. The sum of these three heads is equal to the amount of drop in the water surface that must obtain in the reducing section or to the amount of backwater that may be caused by the change of cross section when no such drop is provided.

The increase of velocity-head accompanying a contraction of cross section should be determined by computing by means of Kutter's formula the velocity in the canal above the reducing section and likewise that in the canal or structure below the same. The difference between these two velocity-heads is the required increase and is expressed by the well known formula below:

$$h_v = \frac{1}{2g}(v_2^2 - v_1^2). \quad \ldots\ldots\ldots\ldots\ldots (1)$$

The discharge from the lower end of the reducing section may be considered as consisting of two parts; that passing through the upper portion above the normal water level under weir action and that passing through the lower portion under submerged orifice action. (See Treatise on Hydraulics, by Mansfield Merriman, p. 327). The average coefficient of discharge for both the weir and the submerged orifice with full contraction is about 0.62, but this value must be corrected for

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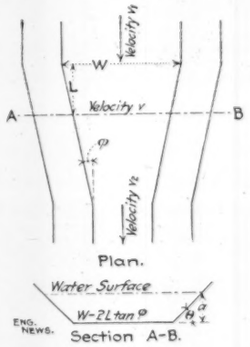
bottom and side suppression. It may be assumed for practical purposes for canals having the usual ratio of width to depth that the coefficient of discharge for full contraction is increased by suppression proportionately to the extent of wetted perimeter suppressed and that the increase for the complete suppression of contraction on the wetted perimeter is about 0.1. (See Hydraulics, by Hamilton Smith, Jr., p. 117; Treatise on Hydraulics, by Mansfield Merriman, p. 129). The general equation, therefore, for the coefficient of discharge may be written in the form of equation (2) below:

$$m = 0.62 + 0.1b \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

When the change in the cross section at the sides of the canal is made by offsets at right angles to the line of flow, full contraction takes place on the sides and suppression occurs at the bottom only. If there is a sudden rise in the canal bed partial or full contraction may exist at the bottom also. When, as is ordinarily the case, there is no abrupt change in grade elevation and when the sides of the reducing section are placed at a definite acute angle with the axis of the canal, full suppression occurs at the bottom and partial suppression at the sides. For this case the equivalent side suppression must be estimated in the absence of experimental data. It will be sufficiently accurate for practical purposes to assume the equivalent side suppression equal to full side suppression multiplied by the cosine of



the angle of splay of the side walls. By giving the foregoing conditions due weight in computing the value of m from equation (2) and applying equation (3) below, the loss of head due to contraction of cross section may be approximately found.

$$h_c = \left(\frac{1}{m} - 1\right)^2 \frac{v_2^2}{2g} \quad \ldots\ldots\ldots\ldots (3)$$

The amount of the friction-head may be negligible, where the reducing section is short, but will be considerable where it is long, as may sometimes be the case in concrete-lined canals. For the purpose of estimating this loss of head, let it be assumed that the depth of water in the reducing channel is constant, that the side slopes of the reducing channel are planes making a constant angle with the surface of the canal bed and that c in Kutter's formula is a constant in the length of the reducing channel under consideration and equal to the arithmetical mean between that at the upper end and that at the lower end of that length based on an assumed slope of the water surface in the reducing section. Now by applying the calculus to determine the value of the friction-head in the Kutter-Chezy formula for the variable velocity and cross section in the reducing channel between the limits of the length under consideration, equation (4) obtains. From the fact that the velocity at any cross section multiplied by the area of that cross section is always equal to the discharge and from the figure, equation (5) follows. Since the hydraulic radius is the quotient obtained by dividing the wetted cross sectional area by the wetted perimeter, equation (6) may be readily deduced from the figure. By substituting the values of v and r from these two equations in equation (4) and integrating between the proper limits, there is obtained equation (7), which is the desired formula for determining the friction-head in the reducing channel.

$$h_f = \frac{1}{c^2} \int_0^L \frac{v^2\, dL}{r} \quad \ldots\ldots\ldots\ldots (4)$$

$$v = \frac{q}{a\,(w + a\cot\theta - 2L\tan\phi)} \quad \ldots\ldots (5)$$

$$r = \frac{(w + a\cot\theta - 2L\tan\phi)\,a}{w + 2a\csc\theta - 2L\tan\phi} \quad \ldots\ldots (6)$$

$$h_f = \frac{q^2}{4a^3 c^2 \tan\phi}\left[\frac{2w + 2a\csc\theta + a\cot\theta - 4L\tan\phi}{(w + a\cot\theta - 2L\tan\phi)^2} - \frac{2w + 2a\csc\theta + a\cot\theta}{(w + a\cot\theta)^2}\right] \quad \ldots\ldots (7)$$

By the summation of the heads computed from equations (1), (3) and (7) the total required head in the reducing section is readily obtained.

The change of a canal cross section to a larger one may or may not be accompanied by a reducing section. In all cases there is a loss of head due to expansion of cross section and a gain of head due to the decrease of velocity-head; and where the reducing section is used, there is a loss of head due to friction as the water passes through it. The amount of the decrease in the velocity-head may be computed directly from equation (1); and the friction loss may be computed by means of equation (7) by changing the sign of the right member and considering the angle ϕ therein to be negative. In determining the loss of head due to expansion of cross section, it may be assumed that the loss is decreased in proportion to the amount of the wetted perimeter on which such expansion is suppressed. As in the contraction of the channel cross section hereinbefore discussed, the suppression may be either complete or partial as to the whole wetted perimeter or as to parts thereof. Where the channel sides are placed at a definite acute angle with the axis of the canal, it will also be sufficiently accurate here in the absence of experimental data as in the case of suppression of contraction, to assume the equivalent side suppression equal to full side suppression multiplied by the cosine of the angle of splay of the side walls. Introducing b into the right member of the ordinary formula for computing loss of head due to expansion of cross section in pipes, equation (8) is obtained.

$$h_e = \frac{(1-b)}{2g}(v_1 - v_2)^2. \quad \ldots\ldots\ldots\ldots (8)$$

By making an algebraic summary of the heads computed from equations (1), (7) and (8), the excess head in the reducing section may be obtained. This surplus head may be disposed of in two ways, either by raising the canal bed by an equal amount at the lower end of the reducing section or by reducing the total fall in the succeeding stretch of canal by an equal amount. If there is abundance of fall in the canal it is better to omit the reducing section and thus destroy as much velocity-head as possible by sudden expansion of cross section. On the other hand if head is a valuable consideration it is better to use the reducing section.

A most valuable and interesting application of equation (7) to the reducing section of a canal is the determination of the profile of the grade of its bed, which profile is a curve as a result of the assumption that the water depth in the reducing section is constant and that the side slopes thereof are planes making a constant angle with its bed. In any channel of this kind with considerable length and very slow change of cross section, the loss due to contraction or expansion of cross section may be neglected. The value of h_v can be computed from equation (1) for a cross section any distance L from the initial end of the reducing section by obtaining v_1 from the conditions of the problem and v_2 from equation (5); also the value of h_f can be obtained from equation (7) for the same cross section. Since H, the total loss of head or fall in the channel grade, is the sum of h_v and h_f, H and L become coordinates for plotting the profile of the grade. Therefore, the curve is readily plotted by assigning values to L and computing as above outlined the corresponding values of H for sufficient points to locate it properly. By combining equations (1) and (7) an equation of the profile of the grade may be obtained, but it is easier to proceed as above outlined.

For the purpose of illustrating the use of equations (1) and (7) in obtaining the profile of the grade of a reducing channel, let it be assumed that it is desired to connect a stretch of concrete lined canal having side slopes of 1 on 1, a water depth of 5 ft., a bottom width of 10.8 ft., a mean velocity of 13 ft. per sec. and, therefore, a capacity of 1,030 second-feet with a stretch having the same side slopes, depth of water and capacity, but having a bottom width of 2.6 ft., and, therefore, a velocity of 27 ft. per sec., by using a reducing section having the same side slopes and the same depth of water as the canal and having a length of 400 ft. and a gradual contraction of the base width from the upper to the lower end.

In finding the average value of c, the slope of the water surface in the length under consideration may be assumed to be that necessary to produce the increase in velocity-head. By substituting values of L in equations (5) and (6), values of v and r can be found at the corresponding distances from the initial end of the reducing channel, from which c may be determined. From the hypotheses of the problem and the hydraulic and geometric conditions of the channel the following values obtain: $a = 5$; $q = 1{,}030$; $\tan\phi = 0.01$; $\csc\theta = 1.4$; and $\cot\theta = 1$. By properly substituting the foregoing values in equations (1) and (7) and assigning values to L, corresponding values of H can be found, whence the co-ordinates of several points in the profile curve are fixed. Below are slide rule computations of the co-ordinates of a few points in the surface or bed curve in question:

L	H
0	0
100	1.2
200	2.9
300	5.4
400	11.1

NOTES FROM ENGINEERING SCHOOLS.

UNIVERSITY OF ILLINOIS.—On Jan. 22 the Trustees voted that the Engineering Experiment Station be authorized to offer ten Research Fellowships in the College of Engineering, of an annual value of $500. Circulars of information concerning these fellowships have just been issued.

Until the present year the University has offered but eight fellowships, each of an annual amount of $300 distributed among the various colleges of the University. Experience has shown that it was difficult to induce desirable men to remain for post-graduate work in engineering at that amount.

Since the organization of the Engineering Experiment Station in 1903, opportunities for doing post-graduate work of high grade, have developed in connection with the research work and experimental investigation carried on there. In order that these research fellowships shall not interfere with those of other departments, it has been required that men accepting them shall remain two years to obtain a second degree. They are thus placed about midway between the usual fellowship of one year and the graduate courses "in absentia" of three years.

It is expected that men accepting these fellowships will devote a certain amount of time to regularly assigned work in the station, aside from their post-graduate studies. These assignments will be along the lines of investigation already laid out by the station. The amount of time may vary according to individual cases, but will not exceed one-half the entire time each year.

Applications will be discouraged from men attracted merely by a $500 fellowship and the prospect of securing the Master's degree, and in making the assignments preference may be given

to men of some experience or training beyond the B. S. degree. The fellowships are open to graduates of American and foreign universities, and technical schools.

Nominations to fellowships are made upon application received by the Engineering Experiment Station each year not later than the first day of February. These nominations are subject to the approval of the Faculty of the Graduate School and the President. Appointments are made in March and take effect the first of September, following.

For further information the "Director of the Engineering Experiment Station," Urbana, Ill., should be addressed.

THE $8,000,000 CONTRACT between the New York Central & Hudson River R. R. Co. and the O'Rourke Engineering & Construction Co., for the excavation of the site for the Grand Central station in New York City, was canceled by mutual agreement on May 29. About three-eighths of the work has been completed. The congestion of traffic on the tracks leading to the station, over which all the excavated material has to be handled, has caused constant delays to the contractors' work and consequent large expense. The damage due to this delay it was practically impossible to estimate with any approach to accuracy, and it was therefore deemed best by the railway company to settle with the contractor, take over his plant and continue the work with company forces. The regular train movement in and out of the Grand Central station when the contract work began was about 800 trains; at present this has increased to 1,023.

THE CONTRACT FOR THE ADDITIONAL TUNNEL through the Bergen Ridge in Jersey City for the Delaware, Lackawanna & Western R. R. has been abandoned by the contractors, the Grace Construction Co., and will be finished by the railway company's own forces, working under direction of the Chief Engineer, Lincoln Bush, M. Am. Soc. C. E.

PILE DRIVING UNDER A COMPLETED SUB-AQUEous tunnel is now being carried on in the twin tubes of the East River tunnel being built by the New York Rapid Transit Commission, from the Battery, in Manhattan, to Joralemon St., Brooklyn. While part of this tunnel is through rock, a length of about 1,200 ft. is in fine sand and a similar length is in coarse sand. To prevent possible settlement in the future and make certain the stability of the tunnel under heavy traffic, the supporting piles are being driven. The Chief Engineer of the Rapid Transit Commission, Mr. Geo. S. Rice, M. Am. Soc. C. E., who has charge of the work for the city, states that the present support of the tunnel is amply sufficient to carry any weight that will come upon it and that the driving of piles is a precaution which will add to public confidence but is not necessary for the safety of the structure. The tunnel, even with its full live load of 2,000 lbs. per foot, weighs less than an equivalent volume of water, and the resistance of the soil is ample to hold it against any movement.

The piles that are being placed are steel cylinders 2 ft. in diameter, filled with concrete, and are being driven in pairs about every 50 ft. The tunnel being under air pressure, several segments of the lining at the bottom are removed and the steel casing is lowered by water jet until firm material is reached, the length varying from 5 to 50 ft. It is then filled with concrete. About a dozen pairs of piles have been sunk in two sections of the tunnel where sand occurs.

SIX VACANCIES exist in the grade of Assistant Civil Engineer, Corps of Civil Engineers, U. S. N., after the two appointments mentioned in our personal column of this issue. An examination of civilian candidates will be held on July 5, positively in New York, and probably also in Chicago. As is stated in that column, it is desired not to fill these vacancies from the line; but this will probably be the last opportunity for appointment from civil life. While there has been a heavy demand for officers for the sea-going branch, increase in the number of midshipmen at the Academy—based on this demand—will, it is thought, provide a sufficient number of graduates each year to supply not only the demands of the line, or fighting branch, but also the staff. Moreover, legislation is expected requiring candidates to be graduates of the Academy; hence these six positions, carrying with them the commission of the President as naval officers, become additionally attractive.

A SERIOUS WRECK at Elyria, Ohio, caused by a collision between two electric cars on the Cleveland & Southwestern Traction Co.'s line, killed seven passengers and injured eight others on May 30. Both cars were filled with Memorial Day excursionists; one was standing, on a straight track in broad daylight—according to press reports—when the other ran at high speed into it. It is said that the floor of the running car sheared along the top of the floor of the other, a statement borne out by the fact that many of those killed and injured had feet and legs cut off.

LOS ANGELES' NEW WATER SUPPLY, described in our issue of Jan. 24, p. 93, is to be voted on at a popular election, June 12, to see whether the proposed bond issue of $23,000,000 shall be approved. Opposition to the plan is said to come from the corporations interested in local water supply and electric power enterprises; and to meet the opposition the local business organizations are preparing to get out a full vote in favor of the bond issue. One thousand citizen workers have volunteered and nearly 500 automobiles and carriages contributed by citizens will assist in bringing voters to the polls.

THE FLORIDA EAST COAST CANAL, described in Engineering News of Aug. 25, 1904, was opened through from St. Augustine to Miami on May 13. The canal now gives an inside passage for light draft vessels for a distance of about 300 miles; the cuts made by the dredges are 60 ft. wide at the water surface and 6½ to 7½ ft. deep. Regular steamboat service is to be maintained through this section. Eventually the channel is to be extended from St. Augustine to the St. Johns River, and when this is accomplished navigation will be open from Jacksonville to Key West, about 500 miles. The enterprise has involved an expenditure of about $2,000,000. Mr. Geo. L. Bradley, of Boston, was President of the company up to his death a year ago. Mr. Geo. F. Miles has been for many years the Managing Director and has been responsible for the conduct of the construction work.

THE GREAT CUNARD TURBINE STEAMER LUSItania, by far the largest vessel afloat, built for a sustained sea speed of 25 knots, is to have her contract trial on June 27, on the Clyde.

COOL DECKS AND CABINS are maintained in a novel manner on several steamers on the Cuyaba River, Brazil. A loose canvas cover is laid on the awning-deck over the first-class cabins and promenade-deck. These are sprinkled continuously by two centrifugal sprinklers similar to the type used for sprinkling lawns. The heat of the sun is absorbed in evaporating water from the canvas instead of passing through into the cabins. The actual temperature in this part of the vessel is considerably reduced by this scheme.

THE COMPETITION FOR DESIGNS FOR CONCRETE dwellings, conducted by the Association of American Portland Cement Manufacturers, has just been concluded. The total amount offered in prizes was about $2,000. There were 208 designs submitted in the competition. The judges of the designs were Messrs. Edgar V. Seeler and Sanford E. Thompson. The judges say in their report:

"We have found a very general lack of familiarity with possible surface finishes and textures in concrete and the methods of securing them. Some of the best designs have fallen short in this respect. A great number of the designers have appreciated the necessity of extreme simplicity of exterior treatment in monolithic construction, while others, whose designs in monolithic construction have many points of excellence, show lack of practical experience by the use of too many corners, angles and projections.

The specifications have in many cases been less complete than we could have wished, but on the whole answer the requirements of the program.

We have no hesitancy in reporting that the competition has been productive of an entirely satisfactory result in the high grade of a greater proportion of designs than would be naturally expected."

PHOTOMETRIC STANDARDS of the United States, England, France and Germany were compared by Dr. E. P. Hyde, of the Bureau of Standards who, last year, took abroad 18 carefully rated incandescent lamps. The standard of light adopted by the Bureau of Standards is the British candle, but the primary unit used is the Hefner amyl-acetate lamp, rated at 0.88 candle power. In each of the above countries these lamps were compared with the official standards. They were divided into two groups. Those of one were rated in a definite fixed position, while the others were rotated and calibrated for mean horizontal candle power. The results have been published by Dr. Hyde in the April issue of the "Bulletin of the Bureau of Standards," and show slight discrepancies in the prevalent primary standards of light. These are the Harcourt pentane, the Hefner amyl-acetate and the Carcel lamps. The discrepancies in the present accepted ratios are commercially negligible, but of sufficient size, from the scientific point of view, to warrant a thorough investigation and re-adjustment of the published ratios. Dr. Hyde, in his article, urges the desirability of adopting an international unit of light now, for as time passes, it will become still more difficult to change the accepted ratings and ratios of the common standards.

THE MANUFACTURE OF ELECTRICAL APPAratus and supplies according to the manufacturing census of 1905 is reported in Bulletin 73, arranged by Mr. T. C. Martin, expert special agent, and published by the Bureau of the Census, Washington, D. C.

Since 1900 all items of the industry have increased as follows: In number of establishments, 34.9%; in capital, 108.1%; in number of wage earners, 43.9%; in amount of wages, 54.7%; in cost of materials, 35.1%; in value of products, 52.3%. The capital invested in 1905 was, roughly, $174,000,000; the value of products was $141,000,000, or about 81.5% of the capitalization. The average number of wage earners in 1905 was 60,466, and the wages, $31,800,000, or about $525 per capita.

The distribution of electrical industries remains about the same as in 1900. New York, Pennsylvania, Illinois, Ohio, Massachusetts, Connecticut, Indiana and New Jersey report 631 out of the total of 784 concerns, or 90.1%, ranking in the order named.

The value of generators and motors produced in the census year was $33,500,000; 13,800 generators of a capacity of 854,000 HP. and a value of $6,970,000 were direct current, and 1,320, of a capacity of 474,000 HP. and a value of $4,110,000, were for alternating current.

The value of motors produced was $22,400,000, or twice as great as that of the generators. The value, average size and number of stationary motors produced increased over 1,900, but those for railway and automobile use had decreased in number and value, but increased in total power.

The production of transformers has nearly doubled and is now valued at $4,470,000, with a HP. of 971,000. This gives a value of approximately $4.60 per HP. Of these transformers, over half the capacity (504,000 HP.) was held by transformers of 50 KW. and over, whose value per HP. was about $2.

The number of arc lamps produced was larger than in 1900, but their value was less. The relative importance of the open and inclosed types has greatly changed. The number of the open arcs fell from 23,700 to 1,750, while the number of the inclosed type rose from 135,000 in 1900 to 193,000, although the increased number of 1905 had, within a small fraction of a per cent., the same value as the lesser number of 1900.

The value of incandescent lamps produced nearly doubled, standing in 1905 at a value of $6,310,000. The chief gain in quantity and value was in the 16-candle power units.

The value of telephone apparatus rose from $10,500,000 to $15,900,000. Illinois leads this branch of electrical industry in both number of factories and total output.

ELECTRIC BAGGAGE TRUCKS are being developed by the Pennsylvania Railroad for use about railway stations. Three distinct types have been built, whose operation is closely watched to bring out the best arrangement. One of these has proved, so far, to be more serviceable than the others. This, in general appearance, is similar to the familiar station truck. It is operated by one man who steers it, with a tongue, in the usual way. The handle is connected by reach rods to bell cranks carrying the two front wheels as in the common automobile construction.

A storage battery of 14 cells, having a capacity of 136 ampere hours is carried in a box fastened to the under side of the platform. Each rear wheel is driven by a 4-pole, 20-volt, series motor, through a double reduction gear. Each motor carries a solenoid brake, which has been found essential for easy operation, and which automatically holds the truck stationary, even on an incline. The control is arranged for two speeds, forward and backward, of four and six miles per hour. The motors operate in series and with a wire resistance on the low speed. Motor current is controlled by two single-pole solenoid switches, one for each speed, enclosed in a box directly in front of the storage battery. The switches are electrically operated by a small contact box on the end of the tongue. This metal contact box is cylindrical and is worked by a rod sliding lengthwise through it. This rod carries a ring-shaped handle, through which the operator's hand slips. A slight movement of the rod starts the motors at the low speed and a continued movement gives the high speed. When the ring is released, a spring returns it to the initial position, and stops the truck. The reversing switch is in the box with the solenoid switches, but is operated by a small lever under the platform.

This type of truck has been in operation about six months and is well liked by the railroad employees. One man easily handles immense loads of baggage and mail.

CONCRETE TELEGRAPH POLES are in service on a mile section of the Pennsylvania R. R. on its Pittsburg, Ft. Wayne & Chicago Division, near Maples, Ind. The poles, which vary in length from 25 to 34 ft., are 8 ins. square at the bottom and taper to a 6-in. square at the

top with 2-in. chamfered edges giving an octagonal appearance above ground. They were reinforced with ½-in. wires running the full length of the pole. Notwithstanding the fact that they were handled and erected with only five days set, owing to certain unavoidable requirements, they have withstood a winter's use and are now in excellent condition. They were set 4 ft. in the ground in a solid foundation of stone screenings. Several tests on similar poles have been made by various electric railways in the middle West with a view toward using them for trolley poles, and within the limits of the experiments which were made on single poles under given strains, the results are very satisfactory.

THE OMAHA CUT-OFF ON THE UNION PACIFIC Ry. involves some very heavy earthwork. The line is being built under the name of the South Omaha & Western Ry.; it begins about three miles west of the union station at Omaha and strikes the main line again at Lane, Neb. The distance is about 23 miles by the old line and only 14 miles by the new line. Within less than 12 miles there are 3,000,000 cu. yds. of excavation, and three of the largest embankments involve the handling of more than 2,500,000 cu. yds. of material. The largest of these embankments contains 1,400,000 cu. yds., and the height from the ground line to sub-grade runs from 60 to 89 ft. The longest is over a mile in length, crossing the valley of Big Papillion Creek. To cross the valley of Little Papillion Creek requires a bank 3,000 ft. long, while the one across Hell Creek valley is 2,500 ft. These valleys are flat and nearly level, and the creeks are not large, but both the Papillion valleys have been at various times entirely covered with water 5 ft. deep. Hell Creek valley is sharp and steep and drains an area subject to sudden and high floods. This has made necessary ample provision for openings to carry off all water that might collect at flood times. In making these embankments the method has been to dump from the top of temporary trestles built to the full height of the elevation.

From the three great cuts 2,500,000 cu. yds. have been excavated. In one cut, with an extreme depth of 87 ft., 2,000,000 cu. yds. of material was moved. This cut is a mile long and more than 400 ft. wide at the top. Four railways are crossed by steel bridges. About 66% of the work is done, and it is expected that track laying will be commenced in November. The line will be double-track, laid with 90-lb. rails. By the heavy expenditures on this line the railway obtains a saving of nine miles in distance and more favorable grades and curvature than on the original line.

A CONVERTIBLE COMBINED AUDITORIUM AND opera-house has been built in St. Paul, Minn. The structure is owned by the city; the funds for building it were supplied in part by a special municipal bond issue and in part by private donation. It fronts on Fourth St., between Washington and Exchange Sts., and runs through to Fifth St., with a ground plan of 180 by 300 ft. The interior is a single open space without partitions, except that a covered arcade or passageway, built throughout of fireproof materials, extends around all sides of the interior. Over this arcade, extending around all four sides of the hall, is a balcony carrying five rows of seats, which projects forward over the arcade. The space under the projection of the balcony is utilized along the sides to form a continuous row of boxes. The side walls of the building, outside of the arcade, are double, each consisting of two parallel walls about 6 ft. apart in the clear. The space between contains stairways from the gallery to the ground floor; these open into the arcade at the floor level, and with the arcade (which forms the side exit from the main floor) constitute a fully protected exit system. The double side walls are connected by transverse arched walls at intervals, and these carry, at a level about 50 ft. above ground, seats for transverse roof-trusses spanning the hall from side to side. The roof trusses are 172 ft. 6½ ins. in span between centers of supports, are spaced 31 ft. 4 ins. apart have horizontal lower chord and pitched upper chord, and support the ceiling of the hall on their lower chords. The ceiling over the rear or Fifth St. part of the hall is horizontal; that over the Fourth St. half is several feet higher and slopes upward toward the Fourth St. end. At the junction between the two portions a disappearing proscenium wall is fitted. This is in two sections, separated by a space 60 ft. wide, the proscenium opening, in the middle of the width of the hall; each section is arranged to lift up vertically into the roof space when the hall is to be used as auditorium, and to lower down to the floor, separating the front from the rear portion, for theater or opera performance. Immediately to the rear of this wall a rigging loft is formed in the roof-space; this is about 90 ft. wide and 46 ft. long from front to rear, and its roof is 92 ft. above the stage floor. Automatic smoke-vents of 900 sq. ft. area are fitted in the roof of the rigging loft. The loft is closed off at the ceiling level by a canvas ceiling curtain when the full hall is used. The floor in front or toward the Fourth St. side of the movable proscenium wall is set with fixed theater chairs. The balcony along either side of this part of the hall is movable as a single section, pivoted at the Fourth St. end and adapted to roll on tracks so as to close inward at the proscenium end to join the movable proscenium wall. When the balcony sections are so drawn in, and the proscenium wall sections lowered, the Fourth St. end of the building is completely closed off from the remainder, except for the proscenium opening (about 60 ft. wide by 40 ft. high). The entire rear of the hall is then available for stage setting, forming the largest stage in the United States. The theater so formed has a seating capacity of about 3,200. When the proscenium wall is raised and the balcony sections shifted back into their outer position, the boxes and the rear portions of the balcony bring the seating capacity up to 5,000. When the rear half of the floor is set with chairs, as for a political convention, the hall seats about 8,000 persons. An electric hoisting motor is fitted in the basement, at the middle of the proscenium wall, and sheaves are arranged in the floor for cables by which the balcony sections are pulled out or in; these balcony sections, when filled with people, weigh about 205 tons each. The movable proscenium wall sections are hung on cables and are raised by electric power.

The structure was designed by Reed & Stem, Architects, of New York and St. Paul, who originated and worked out this convertible auditorium construction. The building was erected very rapidly. Ground was broken about Feb. 1, 1906, and the first performance in the completed auditorium was given in March, 1907. Its total cost, including equipment, but excluding cost of land, was about $450,000. The arrangements for operating the machinery by which the hall is converted into an opera-house have proved successful, the time required for the entire conversion being only about 10 mins.

THE DRAINAGE OF THE KANKAKEE RIVER Valley in Indiana and Illinois has been the subject of a large amount of study by the office of Experiment Stations of the U. S. Department of Agriculture. For 40 years the drainage and reclamation of this area, comprising over a million and a half acres, has been worked on under different projects. At various places the channel has been straightened, cleaned and deepened until now an improved channel extends in one continuous line for one-half the length of the valley. These improvements have been made in the upper part of the valley with the result that the lower half is now much more subject to destructive floods than formerly, on account of the ease and rapidity of the flow through the improved portion. It is on this flood regulation that the U. S. government engineers are now working and a report has recently been presented which provides for securing the results needed. According to the new plans the entire lower part of the river is to be straightened and its gradient increased in order to increase its carrying capacity; a distance of 72 miles is to be shortened to 41.8 miles. This is accomplished by cutting off 84 bends in cuts varying from 150 to 5,550 ft. in length. The new channel, two-thirds of which will be entirely new work, will have a grade of 1 ft. per mile for the upper 30 miles and 6 ins. per mile in the lower 11 miles. It will be sufficient to provide for the greatest floods that may ever be expected; with a carrying capacity large enough to remove in 24 hours an amount of water equal to ⅛-in. in depth over the whole drainage area of the Kankakee above the point where the improvement ends. A description of this valley and the work in progress upon its reclamation at that time was published in Engineering News, v. 28, p. 410, 421, the issue for Nov. 3, 1892.

PERSONALS.

Mr. Henry Miller, of St. Louis, General Manager of the Wabash R. R., has been elected Vice-President.

Mr. Thomas H. Martin has been appointed Superintendent of the Gibson mine, on the Menominee Range, Michigan.

Mr. Wm. E. Defty, M. Am. Inst. M. E., has resigned as Consulting Engineer of the Mina Juarez Co., of Sonora, Mex.

Mr. W. A. Bowles has been appointed Manager of the Hecla Consolidated Mines Co. at Yuma, Ariz., to succeed W. C. Tonkin.

Mr. W. H. Arnold has resigned as Chief Engineer of the Bush Terminal Co., Brooklyn. The resignation took effect on June 1.

Mr. Grant Snyder has taken charge of the Ely Consolidated Copper Co.'s property at Ely, Nevada, to succeed Olas Jeldness, resigned.

Mr. C. F. Shadle has been appointed Chief Engineer of Power Plant and Signal Engineer of the Wabash R. R. terminal at Pittsburg.

Mr. Walter A. Shaw, Assistant City Engineer of Chicago, has resigned to become President of the American Engineering & Construction Co.

Mr. Clifford Wilfley was recently appointed Engineer of the Virginia and Mexico Mine and Smelter Corporation at Hostotipaquillo, Mexico.

Mr. Henry Jurs has been placed in charge of the Mine & Smelter Supply Co., of Denver, one of the largest concerns of the kind in the world.

Prof. Charles G. Hyde, of the University of California, was recently appointed Director of Sanitation for the People's Water Co., Oakland, Cal.

Mr. H. S. Morrow, of San Diego, Cal., has been appointed Secretary of the California State Department of Engineering by State Engineer Ellery.

Mr. Edgar E. Barker, of Grass Valley, Cal., has been appointed by the Globe Consolidated Mining Co. as Chief Engineer of their properties at Globe, Ariz.

Mr. Jean Bart Balcomb at the last meeting of the Board of Directors of the Hudson River Concrete Co. Brooklyn, was elected General Manager of the company.

Mr. B. C. Rich, Assistant Chief Engineer of the Chicago, Indiana and Southern R. R., has been appointed Chief Engineer with headquarters at Gibson, Ind.

Mr. John R. Searles has been placed in charge of the Nevada Copper Mining & Smelting Co. at Goldfield, Nev. He was formely with the American Car & Foundry Co.

Mr. E. H. Flinn, of Detroit, has been elected President of the recently organized Lake Superior Iron & Chemical Co., to fill the vacancy left by the death of J. H. Berry.

Mr. John E. Pettit has been appointed as State Mine Inspector of Utah, to succeed Mr. Gomer Thomas. The latter resigned to take charge of coal mining properties.

Capt. Thomas Pollard has resigned the superintendency of the Wolverine mine, on the Lake Superior copper range, and will assume control of the Victoria property.

Mr. Hazen Brown has been elected Vice-President and General Manager of the Shenandoah Steel Wire Co., Buffalo, to fill the vacancy made by the death of W. W. Gibbs.

Mr. Wm. A. Carlyle, M. Am. Inst. M. E., for seven years General Manager of the Rio Tinto copper mines in Spain, has resigned to take up a consulting practice in London.

Mr. Leo Gluck, Chief Engineer of Mines for the Chicago, Milwaukee & St. Paul Ry., has resigned to become Assistant to the President of the Pittsburg Coal Co., Mr. M. H. Taylor.

Mr. W. A. Seymour has been appointed Chief Engineer of railroad construction for the W. J. Oliver Co. He was formerly Resident Engineer of the Southern Ry. at Knoxville, Tenn.

Mr. M. C. Hamilton was appointed, on June 1, Engineer of Maintenance of Way of the New York, New Haven & Hartford R. R., to succeed Mr. W. J. Black, who has been transferred to other duties.

Mr. Wm. D. Marks, M. Am. Inst. E. E., Consulting Engineer for railway and lighting plants, has removed from Philadelphia and opened new offices at 623-624 Park Row Building, New York City.

Mr. L. C. Bradley, Superintendent of the Scioto Valley Traction Co., at Columbus, O., has resigned to enter the service of a firm of consulting engineers. C. S. Skinner, Master Mechanic, will succeed him.

Mr. Samuel T. Goodyear has been elected President of the New Orleans Great Northern R. R., to fill the vacancy left by the death of his brother, Frank P. Goodyear. M. E. Olmsted, of Harrisburg, Pa., has been elected Vice-President.

Mr. A. C. Terrell has been appointed Division Engineer of the Northern Pacific Ry., at Spokane, Wash., to succeed Mr. L. S. Oakes, resigned. He will superintend engineering matters on the lines between Ellensburg and Trout Creek.

Messrs. L. F. Loree and C. S. Sims, President and General Manager, respectively, of the Delaware & Hudson Co., were elected, on June 1, President and Vice-President, respectively, of the United Traction and Hudson Valley Railway Companies.

Mr. Wm. S. Johnson, M. Am. Soc. C. E., for 12 years Assistant Engineer of the Massachusetts State Board of Health, has opened offices at 101 Tremont St., Boston, for a consulting practice in civil engineering, specializing in sanitary and hydraulic work.

Mr. Greely S. Curtis, M. Am. Soc. M. E., fire department and fire alarm expert of the National Board of Fire Underwriters' Committee of Twenty, has opened offices at 17 Battery Place, New York, as consulting engineer on municipal fire protective facilities.

Mr. Eli T. Conner, M. Am. Inst. M. E., has been appointed to the management of the New River Collieries Co., of the Guggenheim interests, in West Virginia. He was formerly superintendent of the Wyoming division collieries of the Lehigh Valley Coal Co.

Mr. S. W. Brown, Assistant General Superintendent of the Lake Shore & Michigan Southern Ry., has been appointed General Superintendent of the Michigan Central R. R., to succeed Mr. H. C. Nutt, who takes a position at Tacoma with the Northern Pacific Ry.

Mr. C. E. Lindsay, Division Engineer of the New York Central & Hudson River R. R., Mohawk Division, has been appointed Engineer of Maintenance of Way of the electric division with headquarters at New York. Mr. J. D. Newbert succeeds him in his former position.

Mr. John G. Ellendt, Superintendent of Construction for Frank B. Gilbreth and the Underwriters' Engineering & Construction Co., has resigned his position and will hereafter be actively associated as partner with the Concrete Engineering & Supply Co., at 1133 Broadway, New York City.

Mr. Paul Mellen Chamberlain, M. Am. Soc. M. E., has been appointed Chief Engineer of the Underfeed Stoker Co. of America. Mr. Chamberlain has been a well-known member of his profession, and was for a time Assistant Professor of Mechanical Engineering at the Michigan Agricultural College.

Mr. Hood McKay has resigned as Superintendent of the Short Mountain and the Summit Branch coal properties at Lykens and Williamstown, Pa. He will associate himself with the Lehigh Coal & Navigation Co. His successor is Mr. Wm. Auman, former Superintendent of the William Penn mine at Shenandoah.

Mr. Theodore Starrett has resigned the presidency of the Thompson-Starrett Co., of New York, and the executive management of the company's business; he has been elected Chairman of the Board of Directors, and will remain thus connected with the company. Mr. Albert B. Boardman has been elected as his successor.

Mr. D. C. Moon, Assistant General Manager of the Lake Shore & Michigan Southern Ry., has been elected Vice-President of the New York Central & Hudson River R. R., with charge of the Boston & Albany R. R. at Boston. Mr. Moon began his career with the New York Central lines in 1872, as telegraph operator.

Mr. C. B. Clark, of the A. J. Yawger Co., Railway Contractors, Indianapolis, has sold his interest in the company and opened an office in Baltimore to carry on an engineering and contracting business. Mr. Clark was formerly with the C., C., C. & St. L. Ry. as Principal Assistant Engineer and Superintendent of Maintenance.

Mr. John T. Keith has been appointed General Superintendent of the Jeddo mines of G. B. Markle & Co., Jeddo, Pa.; he succeeds Mr. W. H. Smith, Jr., who has held the position for 14 years. Mr. Arthur P. Goedecke will be Assistant Superintendent and Mr. Joseph R. Crague, Mining Engineer, is made Assistant to the General Superintendent.

Mr. Geo. W. Tillson, M. Am. Soc. C. E., former Chief Engineer of the Bureau of Highways, Borough of Brooklyn, New York City, was on May 29 appointed to the same position for the Borough of Manhattan, to succeed Mr. G. W. Olney, resigned. Mr. John C. Sheridan, formerly Assistant Engineer under Mr. Tillson, has been appointed his successor for Brooklyn.

Mr. Wm. Schlafge, former General Master Mechanic of the Erie R. R., has been appointed Assistant Mechanical Superintendent, with headquarters at Meadville, Pa. The former position has been abolished. George F. Hammond, heretofore Mechanical Engineer, has been appointed assistant to Mr. Schlafge at Meadville, and E. G. Chenoweth, draftsman, appointed to succeed Mr. Hammond.

Professors Edgar Marburg, M. Am. Soc. C. E., and Henry W. Spangler, M. Am. Soc. M. E., of the chairs of civil and mechanical engineering respectively at the University of Pennsylvania, with Mr. Thomas C. McBride, Philadelphia Sales Manager of the International Steam Pump. Co., have been appointed by Mayor Reyburn of Philadelphia, as a committee of experts to investigate and report upon the physical condition of the new filtration works under construction at Philadelphia.

Mr. Oscar F. Lackey, Assoc. M. Am. Soc. C. E., former Assistant Engineer of the Harbor Department at Baltimore under the late Major N. H. Hutton, has been appointed Harbor Engineer, to serve the unexpired term in the office vacated by Major Hutton's death. The term expires on Oct. 1 next, and Mr. Lackey will in the intervening months have an opportunity to qualify for appointment for the full four-year term beginning then. He has been second in command in the Harbor Engineer's office for some time, and has previously had considerable experience on the Panama Canal, the Queen Anne's R. R. and in Cuba.

In this column on May 23 it was stated that Col. J. G. D. Knight, Corps of Engineers, U. S. A., had been detailed for service at New York to relieve Col. D. W. Lockwood. That was but a part of the case and was apt to lead to the impression that Col. Lockwood was to be transferred; on the contrary, Col. Knight merely relieves Col. Lockwood of that portion of the river and harbor work known as the "New York work," including Long Island, and the East, Harlem and Hudson Rivers. Col. Lockwood is placed in permanent charge of the work embraced by Northeastern New Jersey, of which he has had temporary charge since the transfer of Col. Livermore.

Mr. Maurice C. Couchot and Mr. E. T. Thurston, Jr., Assoc. Members Am. Soc. C. E., have entered into partnership under the firm name of Couchot and Thurston, with offices in the Atlas Building, San Francisco. Mr. Couchot has conducted a consulting engineering business for some years and is widely known as an expert in structural engineering, and is a pioneer in reinforced concrete, having built one of the first buildings of that type in San Francisco. Mr. Thurston has had a varied experience in general engineering and lately was associated with the Department of Greater Water Supply of the People's Water Company, of Oakland, Cal. The new firm will conduct a general practice as designing and constructing engineers.

Obituary.

Walter S. Cheesman, President of the Denver Union Water Co., died at Denver on May 31 at the age of 69.

Matthew McPherson, who has long been Superintendent of the Colusa-Leonard mine at Butte, died recently of pneumonia.

Sir Charles Mark Palmer, M. P., died in London on June 4 at the age of 85. He was the head of the Palmer Shipbuilding & Iron Co., Ltd., of Jarrow, one of the largest shipbuilding concerns of Great Britain.

Archibald MacArthur, a civil engineer and contractor, and President of the MacArthur Brothers' Co., of Chicago and New York, died on June 1 at Riverside, a suburb of Chicago. He was born in 1834 at Mount Morris, Ill.

Wm. J. Fryer, an architect and consulting engineer, of New York City, and a writer on architectural and engineering subjects, died at his summer home at New Providence, N. J., on June 3. He was the Chairman of the Board of Examiners, a body established by the Greater New York charter as a sort of municipal court of appeals for architects and builders.

Charles E. Hoffman, a well-known mining engineer, died at the home of his son in San Luis Potosi, Mex., on May 20. He was one of the pioneers in California, going there in 1850. In 1859 he was placed in charge of the Enriqueta quicksilver mines in the New Almaden district, California, and managed them until 1867. His mining activities have extended over California, Utah, Nevada and Mexico.

George F. Chapman, Vice-President and General Manager of the United Railroads of San Francisco, died at his home on May 23 of pneumonia—the outcome of a heavy cold contracted through exposure during the early days of the street railway strike. He went to California from New Jersey, where he had worked up from a position on the platform to the control of the operating department of one of New Jersey's largest roads.

Alfred Lee Tyler, a railroad man and one of the founders of the town of Anniston, Ala., died on June 2 at the Waldorf-Astoria, New York; he was 73 years of age. Soon after his graduation from Harvard he entered the service of the Pennsylvania R. R. Co.; later he assisted his father in building the Macon & Western R. R., and was afterwards General Manager of the Philadelphia & Erie R. R. He was active after the war in building iron furnaces in northern Alabama, and was Vice-President and General Manager of the South Carolina R. R. He was one of the oldest members of the Union League and Manhattan Clubs, of New York City.

Major-General Thomas Howard Ruger, U. S. A., retired, died at Stamford, Conn., on June 3. He was born at Lima, N. Y., in 1833. In 1854 he was graduated from West Point and assigned to duty in the Corps of Engineers, being put to work on the defenses about New Orleans. He resigned from the service later and practiced law; at the outbreak of the war, however, he organized a regiment, went to the front as its Lieutenant-Colonel, and became its Colonel. Among other prominent services he has been Superintendent of the U. S. Military Academy and Commander of the Department of the East; he was retired while serving as the latter, in 1897, with the rank of Major-General.

ENGINEERING SOCIETIES.

COMING MEETINGS.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 12-14. Annual meeting at Atlantic City, N. J. Secy., J. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

MASTER CAR BUILDERS' ASSOCIATION.
June 17-19. Annual meeting at Atlantic City, N. J. Secy., J. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

AMERICAN WATER-WORKS ASSOCIATION.
June 17-22. Annual convention at Toronto, Ont. Secy., J. M. Diven, 14 George St., Charleston, S. C.

ASSOCIATION OF RAILWAY TELEGRAPH SUPERINTENDENTS.
June 19, 20. Annual meeting at Atlantic City, N. J. Secy., P. W. Drew, Wisconsin Central Ry., Milwaukee, Wis.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 20-22. Annual meeting at Atlantic City, N. J. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.

ASSOCIATION OF TRANSPORTATION AND CAR ACCOUNTING OFFICERS.
June 25, 26. Annual meeting at St. Paul, Minn. Secy., G. P. Conard, 24 Park Place, New York, N. Y.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
June 25-28. Annual convention at Niagara Falls, N. Y. Secy., Ralph W. Pope, 29 West 39th St., New York City.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.
July 1-3. Annual Meeting at Cleveland, O. Secy., W. T. Magruder, Ohio State University, Columbus, O.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
Annual convention at the City of Mexico, Mexico, beginning July 8. Secy., Charles Warren Hunt, 220 West 57th St., New York City.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ENGINEERS.
Aug. 7-9. Annual meeting at Norfolk, Va. Secy., Frank P. Foster, Corning, N. Y.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ENGINEERS.—The twelfth annual meeting will be held at Norfolk, Va., August 7, 8, and 9, 1907, in the City Hall. Norfolk has been selected as the meeting place not only for its position geographically but also because of the Jamestown Exposition, which will give the delegates a chance to see the very latest developments of the electrical art, which will be on exhibition there. The papers selected for this meeting are of interest to all municipal electricians. They are as follows: "Electrical Inspections and Records," "Modern Application of Storage Batteries," "The Value of Voltmeter and Ammeter Tests for Insulation," "A Modern Fire Alarm Central Office," and "Operation of a Municipal Electric Light Plant."

August 9th has been set aside by the Exposition Management as Municipal Electricians' Day, and special features and attentions will be given to the delegates at the grounds on that day.

NEW YORK ELECTRICAL SOCIETY.—The annual meeting for the election of officers will be held at 8 p. m., Monday, June 10, at the Engineering Societies Building, 29 West 39th St., in Assembly Room No. 2. The following ticket has been nominated by the committee: For President, Albert F. Ganz; for Vice-Presidents, Augustus Post, Theodore Beran, W. L. Conwell; for Secretary, Geo. H. Guy; for Treasurer, H. A. Sinclair.

After the election Dr. Wm. H. Tolman, Director of the American Museum of Safety Devices and Industrial Hygiene, will lecture on "Safety and Security for American Life and Labor." Dr. Tolman will review, with illustrations from European and American museums of electrical and other safety devices, and industrial hygiene, what is being done in this important field. A description will be given of Port Sunlight, an industrial commonwealth, to show how the factory and home conditions of the laborer can be improved; also of Garden City, an English model settlement on which three American communities are now being projected. He will also show a series of views of the International Exposition of Safety Devices and Industrial Hygiene held in New York this year.

WESTERN SOCIETY OF ENGINEERS.—At the meeting held in the society's rooms at Chicago on May 29, Mr. J. W. Schaub read a paper on "A Suggested Development in Railway Track Construction. He pointed out that under present conditions of track construction and engine and train loads the rails are called upon to perform functions and sustain stresses which they are not properly intended or designed to sustain. His proposed plan was to support the ends of the ties upon 10-in. I-beams with wide flanges, connected by transverse tie-rods, thus preventing the sinking of individual ties in the ballast as the load comes upon them. Guard timbers, boxed out over the ties, would hold the ties in position, as on bridge floors. Surfacing would then be effected by jacking and tamping the longitudinal I-beams instead of the ties.

The discussion turned largely upon the question of rail breakages, some speakers considering that the present type of track is largely responsible for the present unsatisfactory and dangerous conditions. As fas as chemical composition is concerned, Mr. Schaub suggested that the phosphorus content is too high in relation to the carbon content. He saw no good reason why the basic Bessemer process should not be used in this country. Mr. Field, of the Illinois Steel Co., presented the matter from the manufacturers standpoint. Mr. Tratman (Associate Editor of Engineering News) suggested that while experiments, changes and progress have been made in locomotives, bridges, etc., practically nothing has been done to develop track construction, which remains practically the same now as 25 years ago. There is plenty of opportunity for experimental work, but although suggestions have been made, none have been carried into effect. The discussion continued until a late hour, and it was voted to call a special meeting to consider the subject at a later date.